SCIENTIFIC AMERICAN SUPPLEMENT. No 1211

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Scientific American, established 1845.
Scientific American Supplement. Vol. XLVII. No. 1211.

NEW YORK, MARCH 18, 1899.

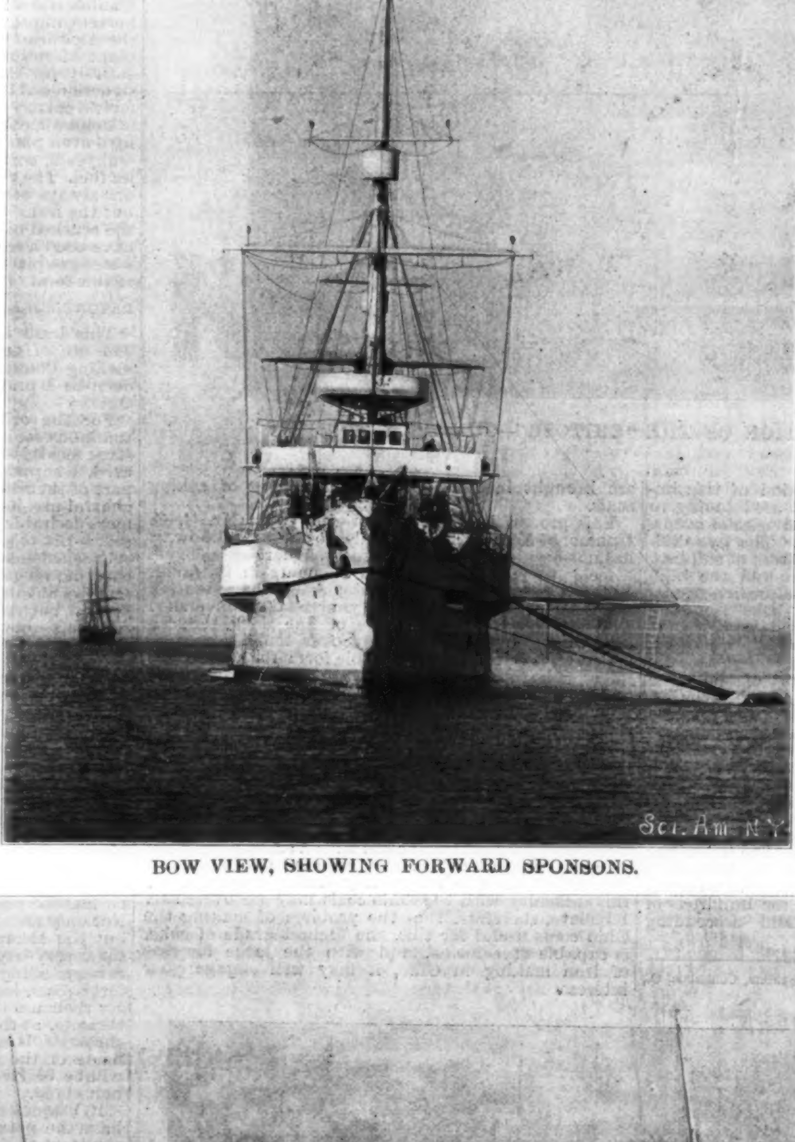
Scientific American Supplement. $5 a year.
Scientific American and Supplement. $7 a year.

THE NEW CRUISER FOR JAPAN.

THE second of the cruisers built in the United States for the imperial navy of Japan has been completed, and has undergone several trials. The "Chitose" was built by the Union Iron Works, of San Francisco. The first rivet was driven May 1, 1897. She was launched January 22, 1898. Though similar in many respects to the "Kasagi," built in Philadelphia, there are essential points of difference, so that the common impression that they are sister ships is scarcely correct. The "Chitose" has no side armor or other protection besides that afforded by her filled coal bunkers. She is fitted with a protective steel deck, and her hatches are guarded by heavy plates. The dimensions of the "Chitose" are: length over all, 405 feet; length between perpendiculars, 376 feet; beam, 49 feet; mean draught, 17 feet 11 inches; displacement actual, 4,865 tons; indicated horse power, 15,500; with a coal capacity of a little over 1,000 tons, or enough to carry her at a speed of 12 knots for 8,000 miles.

The "Chitose" is propelled by twin screws, each driven by a four cylinder, triple expansion engine, with cylinders 40, 60, 66, and 66 inches in diameter respectively, and a stroke of 36 inches. Steam is supplied by 12 single ended, cylindrical, quadruple furnace boilers.

The armament of the "Chitose" on account of its rapid-firing qualities will be more formidable than that of the "Olympia," and will be supplied on the arrival of the cruiser in Japan. It will consist of two 8-inch quick-firing guns, ten 4·7-inch quick-firing rifles mounted in broadside, twelve 12-pounder quick-firing rifles, and six 2·5-inch Hotchkiss rifles. Five torpedo tubes, 14 inches in diameter, are included in the armament. She is also provided with four powerful search lights and numerous steering stations.



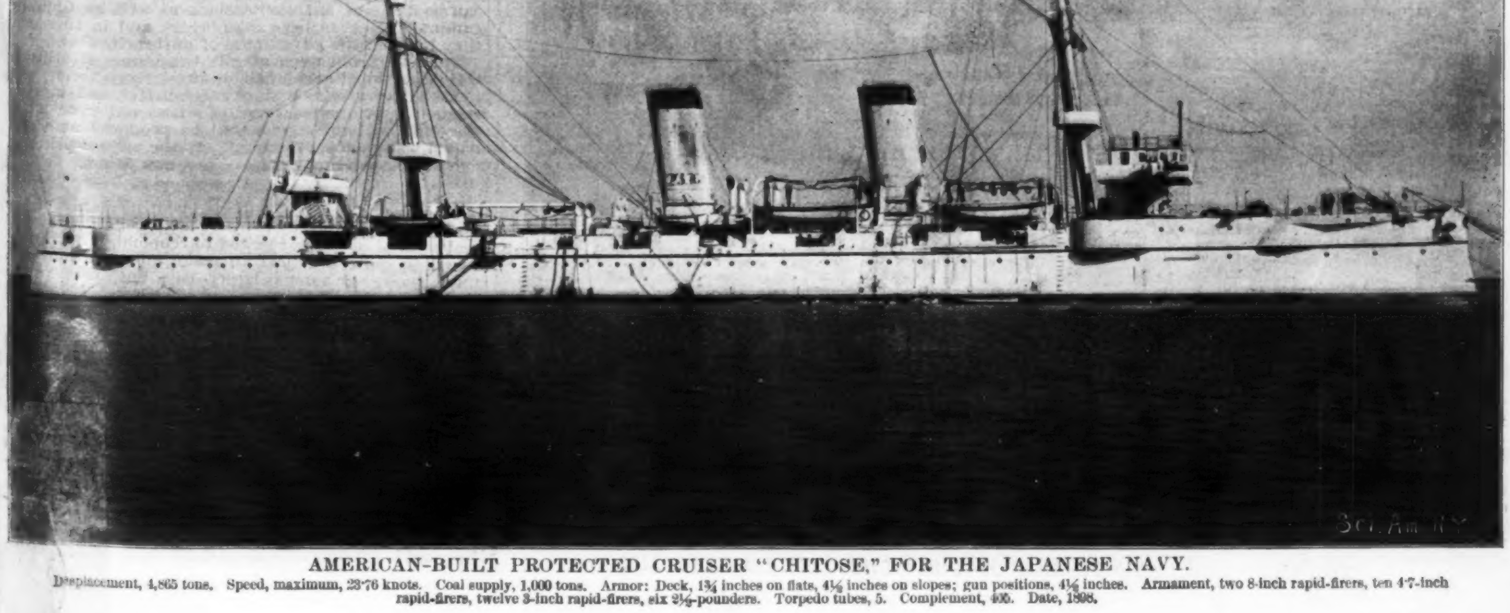
BOW VIEW, SHOWING FORWARD SPONSONS.

The "Chitose" left San Francisco December 28 for a test of her speed over the measured course in Santa Barbara channel, southern coast of California. On December 30 a test was made over a measured base of 10 knots with four turns under forced draught, twice against and twice with the tide, and a speed of 22·67 knots was easily reached. The collapse of the condenser tubes prevented a conclusive and final trial of her maximum speed, which in the opinion of Captain S. Sakurai, Inspector of the Imperial Japanese Navy, would easily have exceeded 23 knots under favorable conditions. On January 3 a trial was made over the 10 knot course with four turns under natural draught, and a speed of 21 knots was attained.

The "Chitose" when fully manned will require a crew of 405 men. The Japanese authorities state that she will be the speediest ship in the imperial navy.

Captain Sakurai regards the "Chitose" as a demonstration of the absolute correctness of the plans under which she was constructed. Before a rivet had been driven it was calculated that the ship would draw 17 feet 7½ inches. The actual draught is only 3½ inches in excess, or 17 feet 11 inches. The contract displacement was 4,760 tons, the actual 4,865 tons, or 105 tons in excess. A margin of 6 inches in draught is allowed by contract. The builders, therefore, had 2½ inches of their allowance left. The "Kasagi's" draught on completion was over 12 inches in excess of contract, but she was accepted notwithstanding.

On February 12 a final and conclusive trial trip of the "Chitose" was made with the most satisfactory results. The machinery worked to a charm, and a run was made to the Farallones and return, the trip occupying about six hours. For two hours and three-quarters the "Chitose" was put to her highest speed, and according to the report of the Japanese inspectors, the maximum reached was 23·10 knots, and the lowest during the trial 22·50 knots. The average was 22·87



AMERICAN-BUILT PROTECTED CRUISER "CHITOSE," FOR THE JAPANESE NAVY.

Displacement, 4,865 tons. Speed, maximum, 23·76 knots. Coal supply, 1,000 tons. Armor: Deck, 1¾ inches on flats, 4½ inches on slopes; gun positions, 4½ inches. Armament, two 8-inch rapid-firers, ten 4·7-inch rapid-firers, twelve 3-inch rapid-firers, six 2½-pounders. Torpedo tubes, 5. Complement, 405. Date, 1898.

knots. Japanese stokers were employed on the trip, and English coal, with which they were unfamiliar, was used.

DOMESTIC COKE AND BRIQUETTES FROM RETORT COKE OVENS.*

By R. M. Atwater, of Syracuse, N. Y.

Gentlemen of the Ohio Institute of Mining Engineers:

Three years ago, by the kindness of your secretary, Mr. Haseltine, I offered to your attention the operation of the retort coke oven. In the interesting discussion that followed this paper, the possibility of using Ohio coals for blast furnace coke was considered, as being a desirable result for the large interests which you represent. I regret to say that but little progress has been made in the practical solution of this important question. Ohio coals are not used to-day to any extent in either retort or bee-hive coke ovens. Still the question is not finally settled. The two difficulties to be overcome are the high content of sulphur, which injures the quality of the iron, and the high percentage of volatile matter in the coal, which results in a soft-bodied coke.

FINE GRINDING OF COAL A PARTIAL SOLUTION.

This same difficulty affects, to an even greater degree, the Illinois coal, and on account of the large requirements of coke in the Chicago blast furnaces, efforts are constantly made to obtain blast furnace coke from these coals. A Chicago engineer claims to be able to eliminate the sulphur from the coke while at a red heat in the coke oven by blowing through it a jet of superheated steam and acetic acid. Even if this result should be accomplished, I doubt if it could be done economically. A well known Pennsylvania engineer has tried to accomplish it by grinding the coal fine and floating it through a pipe line from the mines to the great consuming centers of the middle West. He has demonstrated that coal with an equal weight of water can be transported for hundreds of miles, turning corners, ascending and descending grades, at a lower cost than by rail.

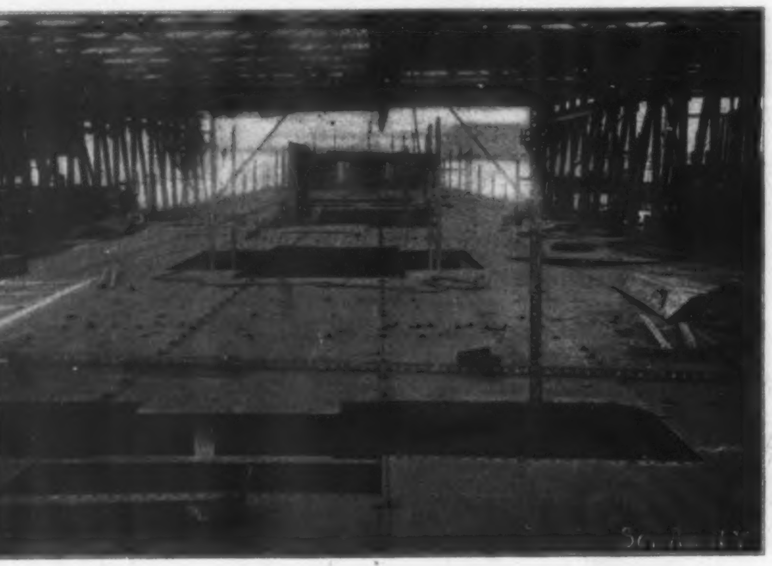
It was expected that one result of the fine grinding would be the reduction of the sulphur, but while there was some reduction it was not enough to make a coal having three or four per cent. sulphur suitable for making blast furnace coke, which should be not over one per cent.

But this fine grinding has advanced the solution of the problem and may yet solve it. It has been found that when coal is ground to pass through a 3-32 mesh, the pyritic sulphur and the float sulphur are both separable to a large extent. So, by means of a riffle, or a jig washer, the heavy pyrites are separated. Then by allowing the overflow of the riffles carrying the good coal and the float sulphur to pass into large settling tanks, the float sulphur is carried off in the overflow, and coals carrying three to four per cent. of sulphur are reduced to less than one per cent., and so are brought into the blast furnace class of coking coals.

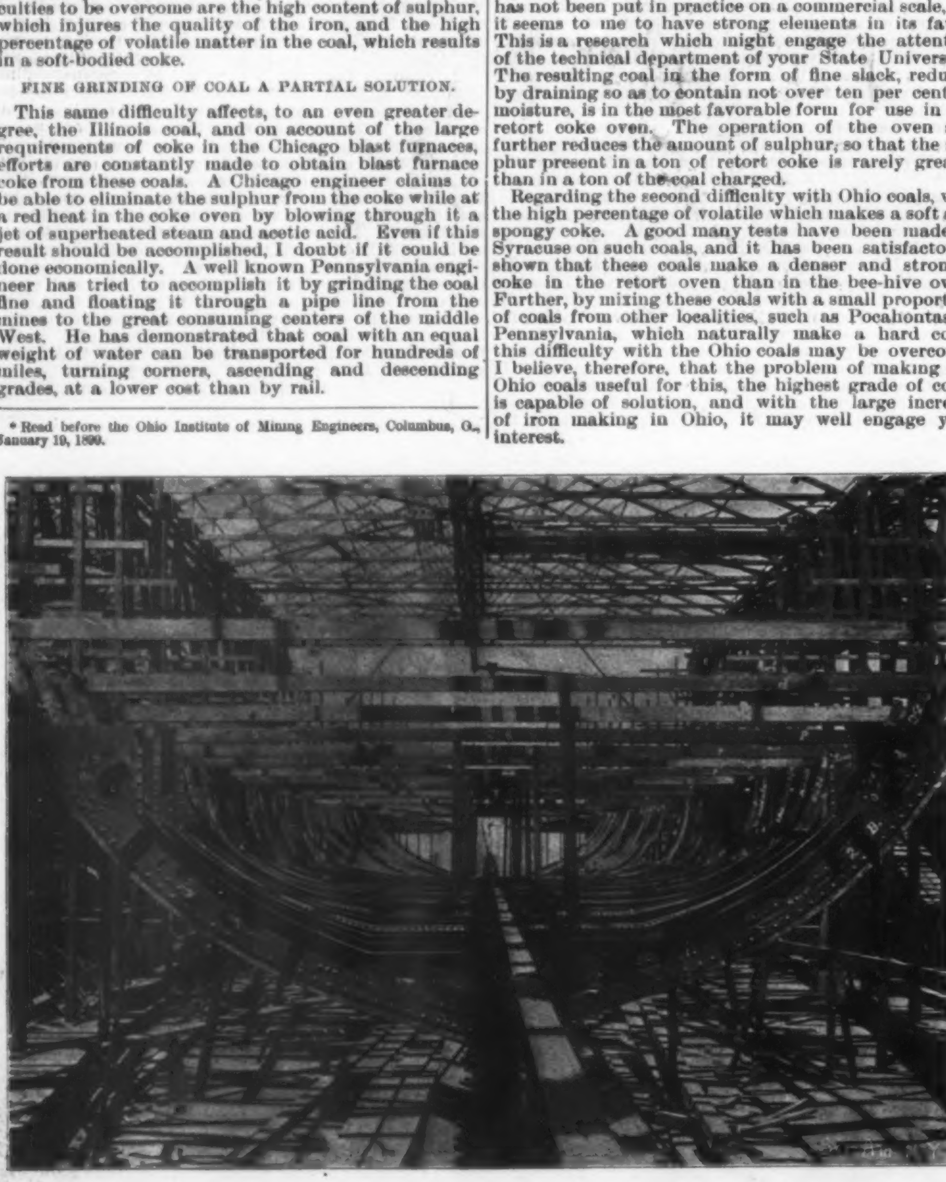
This process is, I believe, original with Mr. C. C. Upham, of New York, and while, so far as I know, it has not been put in practice on a commercial scale, yet it seems to me to have strong elements in its favor. This is a research which might engage the attention of the technical department of your State University. The resulting coal in the form of fine slack, reduced by draining so as to contain not over ten per cent. of moisture, is in the most favorable form for use in the retort coke oven. The operation of the oven still further reduces the amount of sulphur, so that the sulphur present in a ton of retort coke is rarely greater than in a ton of the coal charged.

Regarding the second difficulty with Ohio coals, viz., the high percentage of volatile which makes a soft and spongy coke. A good many tests have been made at Syracuse on such coals, and it has been satisfactorily shown that these coals make a denser and stronger coke in the retort oven than in the bee-hive oven. Further, by mixing these coals with a small proportion of coals from other localities, such as Pocahontas or Pennsylvania, which naturally make a hard coke, this difficulty with the Ohio coals may be overcome. I believe, therefore, that the problem of making the Ohio coals useful for this, the highest grade of coke, is capable of solution, and with the large increase of iron making in Ohio, it may well engage your interest.

* Read before the Ohio Institute of Mining Engineers, Columbus, O., January 19, 1899.



CONSTRUCTION OF THE "CHITOSE"—GUN DECK.



FORWARD KEEL AND FRAMES OF THE "CHITOSE" LOOKING AFT.

RECENT PROGRESS OF RETORT OVENS.

During the last four years, retort oven plants have been put in run in Dunbar, near Connellsville, Pa.; at Sharon, Pa.; Wheeling, W. Va.; and Birmingham, Ala. All these plants make coke for blast furnaces, and the results from each are satisfactory, both technically and financially. The Dunbar furnace, before the retort ovens were started, used exclusively bee-hive coke from Connellsville coal. This has given a good basis for comparison with the best bee-hive coke in the country. The Dunbar furnace has surpassed all previous records while using exclusively retort coke, and owners and manager have given their opinion that the retort coke is better than standard Connellsville beehive coke. All these plants are likely to be enlarged to meet the increased requirements of the furnaces. The plant at Syracuse, N. Y., has already been doubled in size, and for the last year has been supplying foundry coke of a high grade to all the principal iron foundries in the neighborhood of Syracuse.

A plant of retort ovens was built last year at Halifax, N. S., using Dominion coal. Since last June this plant has supplied the illuminating gas used by the city of Halifax. This plant has been able, by a special adaptation of the gas mains, to deliver an unenriched gas of 18 candle power directly into the holders of the Halifax Gas Company. This is perhaps the most important improvement to record in the development of the American retort coke oven. There is also a large plant of retort ovens near McKeesport, Pa., running entirely on domestic coke, and a plant under construction at Boston, Mass., which will also make domestic coke.

Domestic coke is also being produced at many beehive oven plants and has been on the market for several years, competing with anthracite coal as a domestic fuel. The coke produced by illuminating gas plants has always been used to some extent for domestic fuel; but the form and character differ so materially from the crushed oven coke that it can hardly be said to have been a serious competitor. The rapid increase in water gas plants has also tended to decrease the supply of this form of domestic fuel.

RETORT COKE FROM OHIO COALS FOR DOMESTIC USE.

This leads to the main purpose of my paper, viz.: The use of Ohio coals in their present condition for making domestic coke and briquettes in the retort oven as a practical operation for the coal operators of Ohio.

For the ordinary use of the household, lump bituminous coal and anthracite are in general use, while slack coal is not used to any extent. Anthracite is used, I suppose, to a limited extent in the southern part of the State, but in the northern tier of cities is in general use, its freedom from smoke and gas making it more desirable and always preferred when the increased cost is not too great.

Crushed coke differs from lump bituminous coal in carrying no gas or smoke. In this respect it closely resembles anthracite, but on account of its porous character it burns more like bituminous than anthracite. Anthracite burns only on the surface, or until the lump, after becoming red hot, falls to ashes, or melts to clinker. Coke, when it becomes hot enough to burn, burns throughout its whole bulk and from the glowing mass falls quickly to ashes. On this account it occasions some trouble in managing the fire, which goes out quickly when it is not supplied with fresh fuel at a time when anthracite coal would last much longer. Also, on account of its greater bulk, it occupies more room in the stove for a smaller actual amount of fuel.

Fuel briquettes have not been used to any extent in this country, but they have some advantages over any other domestic fuel. They are made in enormous quantities, estimated at 10,000,000 tons, in all the chief coal-producing countries of Europe, and have won a permanent place in the great markets of the world. Not only are they in common use as a domestic fuel, but the locomotives and steamships of Europe use them very largely. They are made of different sizes, corresponding to the market sizes of anthracite coal, for boilers, locomotives, furnaces, grates, and stoves. By their use the waste coal, both bituminous and anthracite, at the mines and in the great coal depots in the cities, is completely utilized. If such a use can be made of the great slack heaps in the Ohio mines, it will be of far-reaching benefit to the miner and the household.

If briquettes are made of bituminous slack, they have the nature of bituminous lump coal, but on account of their density, being pressed as bricks at a great pressure, there is much less waste in dust, and slower and more economical combustion. But they can be made of anthracite slack as well as from bituminous slack, or from coke breeze, and in this form they have all the advantages of anthracite coal.

The retort coke oven affords the means of utilizing Ohio coal in either or all of these three forms, viz.: Crushed coke, soft or smoky briquettes, and hard or smokeless briquettes; and it allows either or all of these forms of domestic fuel to be produced at a cost which will yield a good profit at the selling prices of their corresponding grades of fuel now in use.

DETAILS OF OPERATION.

To make this clear, I will give you the details of the operation of a block of retort ovens, on a practical scale and of a size best suited to economical operation. It will be quite practical to make an operation on a much smaller or a much larger scale, but an operation to produce 100 tons of coke and 100 tons of briquettes per day is a convenient unit to present for your approval and criticism.

The plant will consist of 18 retort coke ovens with all the apparatus for recovering the by-products—ammonia, tar, and gas; also a tar distilling plant for converting the tar into oil and pitch for briquetting; and a briquetting plant for making 100 tons of briquettes in 10 hours. The plant will occupy less than two acres of ground and will cost, exclusive of land and a water supply and railroad connections, about $125,000. Such a plant can be operated in three ways, according to the amount and quality of the product desired.

First, let us consider its operation to produce, as I have said, 100 tons of coke and 100 tons of briquettes

per day on Ohio coking coal. Each oven will take 8 tons of coal and coke it in 24 hours, or 144 tons per day and 52,000 tons per year. The coal will yield 70 per cent. of domestic coke, or 100 tons of coke per day, or 36,000 tons per year. The operation and maintenance in good repair of the plant will cost 40 cents per ton of coke, or $14,400 per year. There will be recovered from the volatile part of the coal in the by-product apparatus 520 tons per year of ammonia, reckoned as sulphate, which has an assured market value of $15,600, or amply sufficient to cover the entire cost of operating the ovens and by-product works. There will also be recovered from the oven gas 2,600 tons of tar, which has a market value of $4 per ton, or $10,400 per year.

After supplying all the heat required for coking the coal and raising steam for all the power required by the ovens and by-product works, there will be left a surplus of 3,000 cubic feet of gas per ton of coal, or 156,000,000 cubic feet of gas, which is worth for manufacturing purposes 5 cents per 1,000 cubic feet, or $7,800 per year. The low value given this gas does not represent its true value, but its actual fuel value in replacing coal and reducing it still lower because it is produced at all hours of the day and all days in the year, and no provision is made for storing it in a holder. The gas carries about 600 heat units per cubic foot and is for many purposes equal in efficiency with natural gas.

It is practically the same as unenriched illuminating gas. If local gas companies will, as has been done in Halifax in the past year, take the gas for their use, it can be enriched by the luminous portion of the fuel gas and can be delivered of 18 candle power. It would, of course, in this case be worth double the amount here estimated for it, and the holders of the illuminating gas company would be available for storing it. Still, at the figure above given, the value of $7,800 per year is sufficient to pay the interest on the investment of money for the whole plant.

The operation thus far stands as follows: The ammonia recovered will cover the cost of operating the ovens and by-product works, while the surplus gas will pay the interest on the investment. I do not state the cost of the coal, for that is a local matter. I also consider that any operation likely to be undertaken will be in the interest of coal operators. The value of the tar stands as a clear profit, and a ton of crushed coke costs only the coal required to make it. As it takes 1·4 tons of coal to make one ton of coke, if coal costs at the ovens $1 per ton, the cost of one ton of crushed coke is $1.40. If coal costs 50 cents per ton, a ton of coke costs 70 cents, and the $10,000 worth of tar is a profit or asset beyond this cost of the coke. As anthracite coal is worth $5.50 in the Columbus market to-day, the operation seems attractive.

THE MAKING OF BRIQUETTES.

Taking up the second part of the operation—the making of briquettes—we will consider that the tar will have to be distilled. The cost of the distilling plant, about $5,000, I have included in the total of $125,000 for the whole plant, also the cost of the briquetting plant, $20,000. The distillation of the tar is a very simple operation, and the oils produced have sufficient value to pay for the cost of the distillation. We may, therefore, consider the 2,600 tons of tar as equal to 1,800 tons of pitch, which is the material used for cementing or binding the briquettes. If pitch alone is used for the bind, it takes 8 per cent. of the coal. If lime is used with the pitch, 5 per cent., 1,800 tons of pitch will therefore supply the bind for 36,000 tons of briquettes per year, or 100 tons per day.

The cost of operating the briquetting plant on the basis of 100 tons per day of 10 hours is given me by parties claiming to be familiar with the business as 25 to 30 cents per ton of finished product. As 100 tons of coal will make 108 tons of briquettes, we may say that 50 cents per ton of briquettes is a sufficient figure for the cost of manufacture, not counting the value of the pitch, which is a clear profit from the coking part of the operation.

We, therefore, have 100 tons of briquettes which cost what 100 tons of slack coal cost plus 50 cents per ton. If the coal cost $1 per ton, the briquettes cost $1.50 per ton, and will sell in competition with lump coal and be preferred on account of their uniformity of size and cleaner condition. Summing up the whole operation briefly, we have, after paying all operating expenses and interest on the investment, 100 tons of crushed coke, costing the value of 140 tons of slack coal and 100 tons of soft coal briquettes, costing the value of 100 tons of slack coal plus 50 cents per ton. The value of the coal at any point where the plant may be located can be supplied and also the competing value of anthracite against the crushed coke or of lump coal against the briquettes.

ALTERNATIVE PLANS OF TREATMENT.

Two other methods of operation are, however, worth our consideration. As I said before, briquettes may be either made from soft coal, and consequently smoky, or from anthracite slack, or coke breeze or even Pocahontas slack, in which case they will be smokeless and in every way equal to anthracite. For this purpose the coke may be ground to a fine powder and the pitch used to make smokeless briquettes, which should command the full price of anthracite coal. On this basis the operation will stand as follows: 108 tons of smokeless briquettes will cost the value of 140 tons of bituminous slack coal plus 50 cents per ton. If this slack costs $1 per ton, the cost of these briquettes will be $1.80 per ton. If the coal costs 50 cents per ton, the briquettes will cost $1.15 per ton.

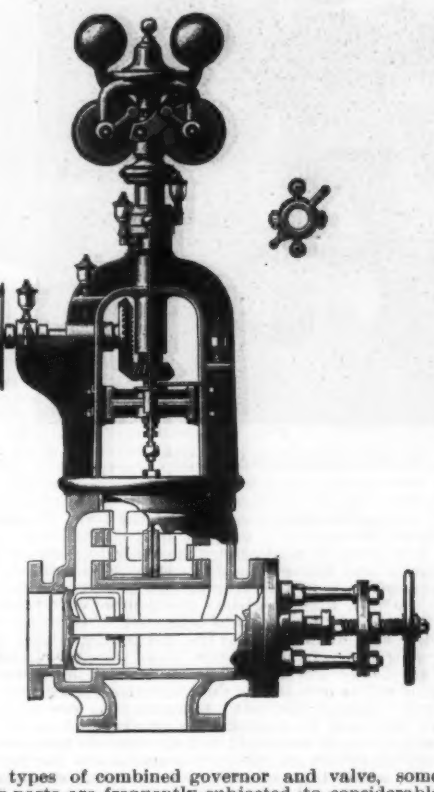
The other method of operation is of interest in view of the large quantities of non-coking coal in the Hocking Valley region. This slack coal is considered of no value at the mines, and its cost at any operating plant is simply its freight. This coal can be charged into the coke ovens and all the volatile distilled off and the tar, ammonia, and gas recovered precisely as is the case with coking coal. The resulting carbon will be drawn from the oven, quenched and passed through rollers to make it of suitable fineness, and made into smokeless briquettes which will compete with anthracite coal. The cost will be the same as briquettes from crushed coke, but the coal may be of lower cost and the operation yield a greater profit.

These three forms of operation may be carried on in the same plant either simultaneously or at different times according to the conditions of the market for the several products. In general it may be said that coal is the cheapest form in which the various products, tar, ammonia, gas, coke, and briquettes, can be transported, as the freight rates on coal are on the lowest basis of all commodities. Therefore, in selecting a place for the operation the preference should be given to that place affording the best market for all the products. The consumption of anthracite coal at the place for the operation is also an important element, as it is easier to displace an article in common use than to create a market for a superior article.

The literature on the subject of briquettes may be found in the following: Engineering and Mining Journal, October 12, 1895; Cassier's Magazine, November, 1896, and December, 1897; Mineral Industries, vol. vi., 1898.

SPECIAL GOVERNOR FOR HEAVY ENGINES.

IT is a well known fact in connection with steam engine practice that in the larger sizes of the ordi-



nary types of combined governor and valve, some of the parts are frequently subjected to considerable wear, chiefly owing to the want of efficient lubrication, and a good deal of trouble and expense is generally involved in replacing or repairing the worn parts, on account of the difficulty of handling the great weights of the governor. Messrs. Schäffer & Budenburg, of Manchester, London, and Glasgow, have recently patented the governor shown in the accompanying illustration, which is designed to overcome the difficulties above referred to. In this apparatus all the chief parts subject to wear can be kept in a state of perfect lubrication, a number of lubricators with adjustable sight-feed being provided for this purpose. Wherever possible there are also provided simple adjustments for taking up all wear, and the whole of the wearing parts are made easily accessible, so that any of them can be readily replaced whenever this may be necessary, without disturbing the governor head or other heavy portions of the apparatus. A strong bridge bolted to the frame is provided for carrying the heavy rotating masses of the governor. The main revolving spindle which supports the governor head, and upon which is fixed the horizontal bevel wheel, is carried in a step-bearing arranged in this bridge. The wear in the step bearing can be taken up by a simple set-screw adjustment to allow of restoring the perfect engagement of the wheels in case of any wear. The horizontal bevel wheel is "under-driven," so that it cannot press upon the vertical bevel wheel in consequence of wear in the step-bearing. The end of the driving shaft is mounted in an adjustable bearing, on each side of which adjustable collars are fitted for the purpose of regulating the engagement of the vertical bevel wheel at the end of the shaft. Both bevel wheels can thus be maintained in perfect gear. The throttle valve is supported from the governor sleeve by means of two rods, each guided top and bottom. These rods are connected with corresponding cross pieces, between which the lengths of the rods are adjustable, to allow of altering the position of the valve if required. The governor sleeve itself is fitted with a bush in two halves, and the bush when worn out can be readily renewed at a very small cost. This special form of governor, it may be added, is designed exclusively for the heavy class of stationary land engines, and is only applicable to steam pipes of from seven inches diameter upward. We are indebted to The Marine Engineer for the article and engraving.

HYDRAULIC INTENSIFIER PUMP FOR LARGE TUNNELING SHIELDS.

WE illustrate below a new intensifier pump for use with large tunneling shields, which is now being supplied by Messrs. Hayward Tyler & Company, and which has a number of interesting points. The intensifier consists of a central motor cylinder placed between two pump cylinders, and separated from them by means of cast iron distance pieces. The motor cylinder is 7 inches in diameter; it is of cast iron. It is fitted with a gun metal piston, which is provided with two gun metal piston rods, 3 inches in diameter, which are elongated to form the plungers of the high pressure pumps. This piston is made all in one piece with its piston-rods. The pump barrels are of gun metal, as also are the valve boxes, valves, and springs. There is a special valve gear for the motor cylinder, with an auxiliary valve for actuating the main slide, which auxiliary valve is worked by a lever from the pump plunger. At each end of the motor cylinder is fixed a small gun-metal valve, by means of which the speed of the pump can be regulated. U leathers and packing rings of special form are fitted to all working parts, and white metal rings are used for the joints of all flanges. The exhaust from the motor cylinder is discharged into a receiver, from which the pump plungers suck, so that the water from the working cylinder is used again for the high pressure. This receiver is provided with a siphon pipe as shown, to insure a constant supply of water from the pumps. The intensifier is designed for working with a pressure of 750 pounds per square inch in the motor cylinder, which is increased to a pressure of 2,240 pounds per square inch in the pumps, which are provided with spring relief valves arranged to blow off at this pressure. The speed of the intensifier is thirty double strokes per minute. We are indebted to London Engineer for the engraving and article.

Nine hundred and fifty thousand feet B. M. of selected timber was shipped from San Francisco on January 28 to be used by the German government in the construction of new war vessels, says Engineering News. The pieces were from 24 to 54 feet long by 4 × 4 feet, and they were absolutely knotless and apparently without a single blemish. The cargo was valued at $27,550, or 4·66 cents per foot, while ordinary lumber sells for about 2·75 cents per foot.

HYDRAULIC INTENSIFIER.

SUBMARINE SURVEY.

By CHARLES BRIGHT, F.R.S.E., A.M. Inst. C.E.

SOUNDING MACHINES.

IT was Sir William Thomson's arrangement of applying an increasing brake power to the drum of wire as it paid out which brought about the universal adoption of steel wire for sounding purposes. For paying out the wire, and also for its recovery, an entirely new machine was needed to replace the heavy and cumbrous winches used in the case of the hemp lines which had hitherto been employed, and Sir W. Thomson (now Lord Kelvin) was not long in devising a suitable machine. The principle on which Sir W. Thomson sounded made it necessary for the drum on which the length of wire was coiled to be as light as possible, or its inertia would cause it to run on after the sinker had come to rest on the bottom.* It was soon found by experience that a drum thus lightly constructed would not be sufficiently strong to resist the compression put upon it when the wire was picked up under strain. Every turn of wire at a 30-pound strain imposes equal compressing strain on the drum; and supposing there were 2,000 such turns, the total compression would amount to 60,000 pounds; to resist this would require a much heavier drum than was considered advisable to employ. Just as when sounding by the old method, with hemp lines, a winch is used to pick up the line, and it is then coiled away on a drum, so in the sounding machine a similar arrangement is used to pick up the wire, and it is then coiled away on a drum, which in this case is driven from the shaft of the picking-up wheel.

The Silvertown Company were first and foremost in taking up Sir William Thomson's method of sounding. They greatly improved on the apparatus (see Fig. 1)—partly by applying a self-adjustable balance to the brake—and took a number of soundings in connection with the laying of a cable from the Lizard to Bilbao in the same year—1872. This company have ever since been inveterate in submarine research work for the purposes of cable projects, and have really led the way in this respect. Particulars of their early sounding work, and of the improved Thomson machine employed by them, were furnished by Mr. E. March Webb in 1879, during the course of a paper read before the Society of Telegraph Engineers regarding the Marseilles-Algiers cable expedition of that year.*

The United States navy were scarcely less speedy in recognizing the features of the Thomson method, for in 1874 a complete set of wire sounding machinery was fitted to the United States survey ship Blake, from the designs of Captain Sigsbee, U.S.N. This machine was for many years one of the best in existence. Designed for a midship position, it is particularly suited for a small and lively ship. Its principal parts (see Fig. 2) are the drum, *A*, on which is wound the wire, the auxiliary pulley, *B*, used while heaving in to relieve drum of the strain, the jockey wheel, *C*, the swivel pulley, *D*, the accumulator contained in the tube, *H*, and the brake, *E*.

The drum is made light, in order to have as little inertia and momentum to overcome as possible. Its circumference is one fathom. An indicator is attached to the axle, which registers the number of revolutions. The auxiliary pulley, *B*, is composed of three pulleys—one for the wire, one for the belt going to the drum, and the other for the belt from the driving engine. The jockey wheel, *C*, is an ordinary gun metal one with a V-shaped score, and the wire passes over this both in paying out and reeling in. Its circumference is 3 feet, and an odometer being attached to its axle, the amount of wire paid out can thus be obtained. A very important feature in this machine is the accumulator, which is composed of spiral springs contained in two vertical tubes, one of which is shown at *H*. These springs are connected with the crosshead of the jockey wheel by means of chains passing over the pulley, *K*. The crosshead moves in steel slides, and rises and falls as the weight on the wire varies, indicating on a scale the strain in pounds. This machine being placed at the side of the vessel, it was found that the rolling of the ship interfered with the work very much. To remedy this, an ingenious governor was devised by Captain Sigsbee, U. S. N., making use of the rise and fall of the crosshead to regulate the brake power. The swivel pulley, *D*, is constructed to allow the wire to be reeled in at any angle when the ship is going ahead.

Johnson and Phillips' Machine.—The illustration given in Fig. 3 shows a very excellent sounding machine, designed on improved principles, to be placed well inboard at the bow or the stern of the ship. *A* is the drum, which is made of gun metal, and is capable of holding some 5,000 fathoms of wire. It is provided with a groove round which passes the brake cord, *B*, actuated by the levers, *C*, on which weights can be placed if desired. From the drum the wire passes to the V-wheel, *D*, which is exactly half a fathom in circumference, and to which a counter, *M*, is attached showing on a dial the number of fathoms of wire out.* This V-wheel during paying out is loose on its shaft, and is employed merely as a measurer. From here the wire passes along to the ship's bulwark, or rail, and over a small caster pulley which is carried well outboard on a lever pivoted on the rail. This balance bar lever acts as an accumulator, and indirectly influences the brake power. The tail end of the lever is held down by a number of India rubber springs. When any sudden strain comes on the wire, owing to the movement of the ship, the end of the lever is depressed and the wire is often by this means saved from breakage. An ordinary spring balance can be placed between the end of the India rubber springs and the deck. This balance answers as a highly sensitive dynamometer for showing the strain on the wire. On picking up, the wheel, *D*, is fastened to its shaft by the insertion of a key, and is driven by the small three-cylinder Brotherhood engine, *E*. As a rule, a couple of turns of wire are put round it. As the wire comes in, it is coiled away on the drum, *A*, which is driven by the cord, *F*. Care must be taken to see that the wire goes on to the drum slack; and to insure this, the cord, *F*, should readily slip. It has frequently happened that with inexperienced hands the cord has been too tight, with the result that the wire has been broken between the drum and the wheel, *D*.

The above machine has been extensively employed on the cable ships of the Eastern and allied telegraph companies.

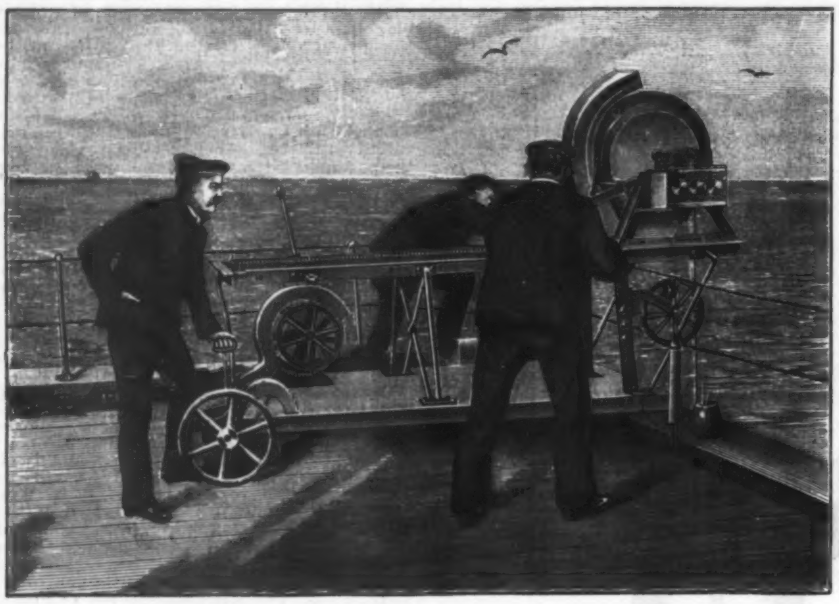


FIG. 1.—SILVERTOWN STEEL WIRE SOUND MACHINE.

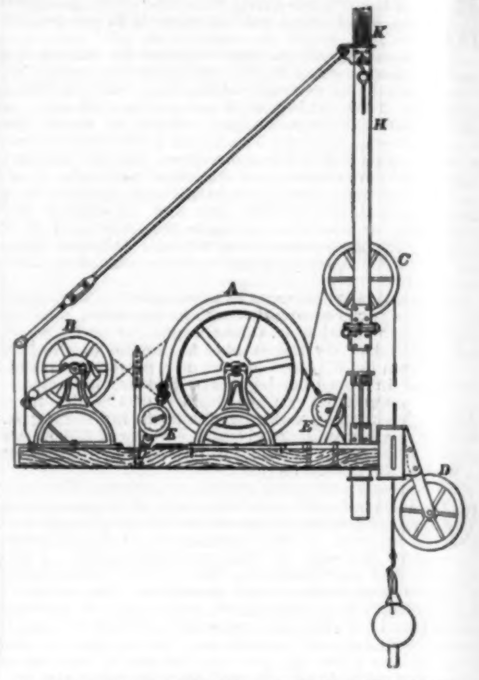


FIG. 2.—THE SIGSBEE STEAM SOUNDING MACHINE.

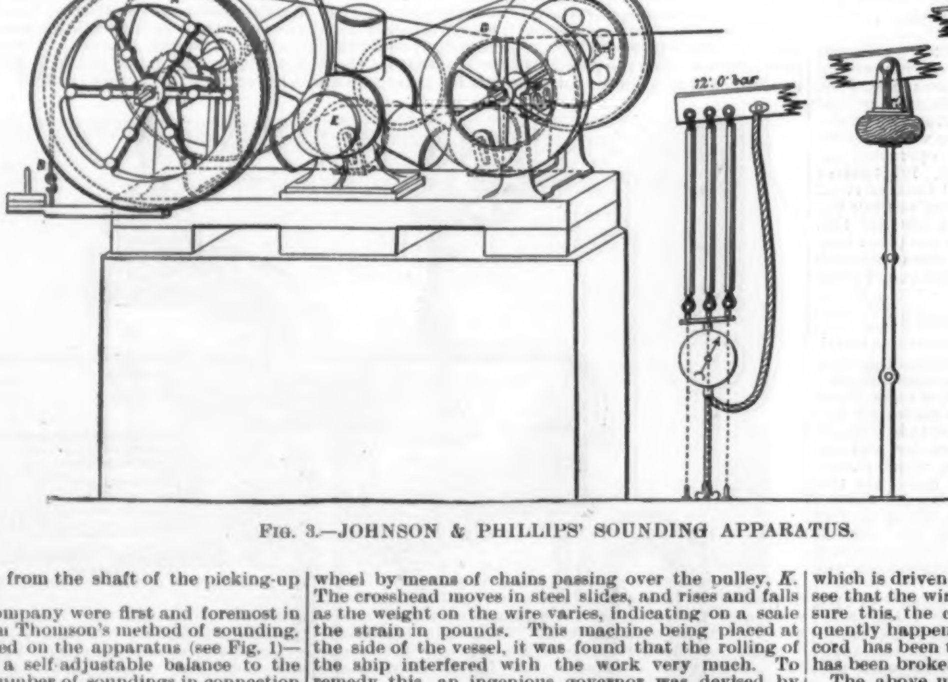


FIG. 3.—JOHNSON & PHILLIPS' SOUNDING APPARATUS.

* The above, in fact, consisted of a very thin galvanized iron drum one fathom in circumference.

* See Journal of the Institution of Electrical Engineers, vol. viii., page 454.

* The above plan was a manifest improvement on that hitherto in vogue. Previously, no separate measuring drum had been employed, the indicator being connected to the drum holding the entire length of wire. Inasmuch as the outside turns were naturally considerably longer than those inside, a correction had to be applied to arrive at the true length of wire board from the number of revolutions indicated by the counter. quite apart from any correction for the true depth on the score of the not being straight "up and down," such as is often involved.

The Lucas Automatic "Sounder" (Patent No. 15,012 of 1887).—This machine, designed by Mr. F. R. Lucas, and used by the Telegraph Construction and Maintenance Company, as well as on the repairing ship of the Eastern Telegraph Company, etc., is shown in Fig. 4. It is intended for use in depths up to 4,000 fathoms, and is fitted with a grooved wheel, *A*, for driving by a rope band from a steam winch or other engine. The wire is coiled on the drum, *B*, and is paid out round a measuring wheel, *C*, the revolutions of which record on a dial the number of fathoms out. A spring brake, which is capable of stopping the wire instantly, is kept out of action by the tension of the wire during the run out, but when the sinker strikes bottom, the loss of tension at once allows the brake to spring back and

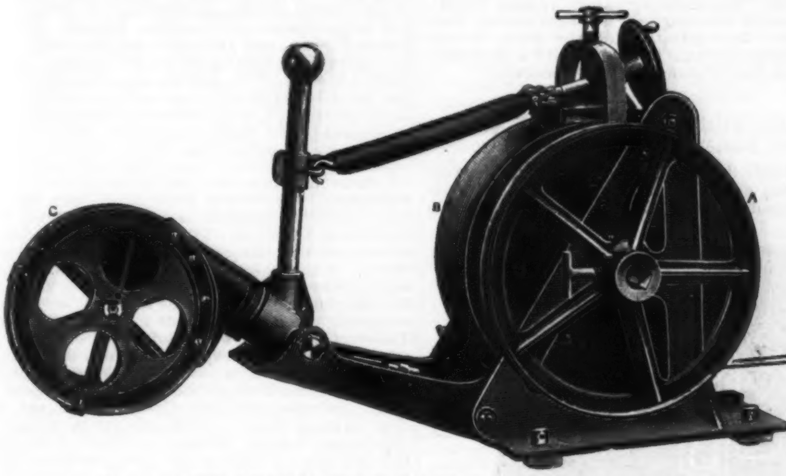


FIG. 4.—THE LUCAS STEAM-SOUNDER FOR DEEP WATER.

stop the drum.* The depth can then be read off the dial with fair accuracy.

Another smaller machine of Mr. Lucas—somewhat modified in principle, and weighing only about 32 pounds—is also employed by the Telegraph Construction Company. It is shown in Fig. 5 and is an exceedingly useful machine for shallow water, being particularly well adapted for use in steam launches or boats. The drum holds about 400 turns of wire; but as the recovery has to be effected by hand, the machine is scarcely suitable for depths anywhere approaching that figure. Both these Lucas machines are intended to be placed on the rail of the ship, and the wire must hang vertically.

Siemens Bathometer.—Finally, with regard to the apparatus employed, we should mention that at the Royal Society in 1876, the late Sir William Siemens, F.R.S., described an ingenious method of ascertaining the depth without taking a sounding. This was based on the principle that the total effect of gravitation at the earth's surface is the resultant of the separate attractions of all particles of matter, and that the attractive influence of different substances varies directly as the density, and inversely as the square of their distances. He gave the name of "bathometer" to the instrument devised on the above principle. Though perfectly sound in theory, it is believed that the apparatus was found impracticable for aboardship work; and, therefore, we refrain from describing it.

For further detailed information regarding some of

FIG. 5.—THE LUCAS HAND-SOUNDER FOR SHALLOW WATER.

the apparatus employed in submarine survey, the reader is referred to an excellent paper by Mr. Stallibrass, read before the Society of Telegraph Engineers in 1887.†

SPEED OF SOUNDING.

From a number of soundings, the aggregate depth of which was 144,500 fathoms, the mean rate of paying out was 99 fathoms per minute, and of recovery 90 fathoms per minute. This was with the use of the Silvertown machine. By means of the same apparatus a sounding in 1,000 fathoms has been taken by the twin-screw "International" in 18 minutes 16 seconds, in 1,500 fathoms in 27 minutes 15 seconds, and in 2,000 fathoms in 37 minutes 45 seconds.

With an ordinary sinker of the first pattern described (weighing from 30 pounds to 40 pounds), an average rate of 100 fathoms in 70 to 80 seconds—or 100 fathoms per minute with a 60 pound shot—may be easily attained, both for paying out and heaving up the wire. From 35 to 40 minutes is about the time required to complete a sounding in say 1,500 fathoms, inclusive of the necessary interval between the two portions of the operation, while the tube is at the bottom.

Time may be saved by steaming ahead while the wire is being hove in; and during a long series of soundings, when the depth only is of importance, the gain thus effected may be considerable. The specimen, however—especially when the bottom is soft—is liable to be sucked out of the tube when the latter is towed rapidly through the water. Moreover, accidents to the wire are by no means of rare occurrence when heaving in from very deep water, and the risk of parting the wire is greatly increased when steaming ahead. On this account it is, perhaps, more satisfactory to wait till the tube is recovered and a good specimen obtained.

We are indebted to London Engineering for the above description and engravings.

* It is in this sense that the machine is styled "automatic."

† "On Deep Sea Sounding in Connection with Submarine Telegraphy," by Mr. Edward Stallibrass, A.M. Inst. C.E. (Journal of the Institution of Electrical Engineers, vol. xvi.)

THE CONSTITUTION OF THE ELECTRIC SPARK.*

By ARTHUR SCHUSTER, F.R.S., and G. HEMSALECH.

WHEN an electric spark passes between metallic electrodes, the spectrum of the metal appears, not only in immediate contact with the electrodes, but stretches often across from pole to pole. It follows that during the short time of the duration of the spark the metal vapors must be able to diffuse through measurable distances.

The following investigation was undertaken primarily to measure this velocity of diffusion with the special view of comparing different metals and different lines of the same metal.

Feddersen published, in the year 1862, an interesting research, in which photographs of sparks passing between different metal poles are taken after reflection from a rotating mirror. He could from his experiments draw some conclusions which have a bearing on our subject, but it was necessary for our purpose that the light should also be sent through a spectroscope, so as to distinguish between the luminous particles of air and those of the metal poles.

The method of the rotating mirror tried during the course of several years in various forms by one of us did not prove successful. On the other hand, good results were obtained at once on trying the method used by Professor Dixon in his researches on explosive waves. This method consists in fixing a photographic film round the rim of a rotating wheel. All that is necessary for its success is to have sparks so powerful that each single one gives a good impression of its spectrum on the film. Were the sparks absolutely instantaneous, the images taken on the rotating wheel would be identical with those developed on a stationary plate, but on trial this is found not to be the case. The metal lines are found to be inclined and curved when the wheel rotates, and their inclination serves to measure the rate of diffusion of the metallic particles. The air lines, on the other hand, remain straight, though slightly widened.

To avoid the tendency of the film to fly off the wheel when fixed round its rim, as in the original form of the apparatus, a spinning disk was constructed for us by the Cambridge Scientific Instrument Company. The film is placed flat against the disk, and is kept in place by a second smaller disk, which can be screwed lightly to the first. The diameters of the two disks are 33 and 22·2 cm., the photographs being taken in the annular space of 10·8 cm., left uncovered by the smaller disk. An electric motor drives the disk, and we have obtained velocities of 170 turns per second, though in our experiments the number of revolutions was generally about 120, giving a linear velocity of about 100 meters-second for that part of the film on which the photograph was taken.

The electric discharges were obtained from a battery of six Leyden jars, having a total capacity of 0·033 microfarad, and being charged from an induction machine constructed for us by Mr. H. C. Wimshurst. This machine has twelve plates of 62 cm. diameter and gives sparks which are 13 inches long.

The electrodes were, as a rule, placed 1 cm. apart, and an image of the spark was projected on the slit of the spectroscope, the distance of the slit from the electrodes being equal to four times the focal length of the projecting lens, so that the image was equal in size to the spark. The prism used was made by Steinheil, and had a refracting angle of 60°.

We now pass to the description of the results obtained when the spectrum of a single spark is taken on a moving film. A preliminary trial with various metallic electrodes had shown us that the sharpest results were obtained with zinc, and we therefore chose that metal for our first investigation. The principal lines of zinc as they appear on our photographs are the double line, the least refrangible of the two having a wave-length 4924·8, and the blue triplet, the wave-length of the leading line being 4810·7. All the lines are curved on the photographs taken with the spinning disk, but the displacements, especially near the poles, are subject to considerable variations. This is probably due to the fact that the path of the metallic particles is not always straight, and, if straight, its image does not necessarily coincide with the slit. A very slight error in measurement will also affect the results considerably when the total displacement measured is small. Our results do not for this reason allow us at present to give any opinion as to the maximum velocity of the particles near the pole; but if these are considerable, they drop down very quickly to speeds which, in the case of zinc, are not far off 500 meters-second.

We have adopted two methods of comparison between different photographs. We have in the first place measured the displacements at a number of nearly equidistant points, and from these measurements we have deduced the time taken for a metallic molecule to pass from the pole to a point 2 mm. away from it. If this method could be applied in every case, it would form a rational and consistent basis of comparison. But the curved lines which are to be measured are often very diffuse near the pole; this, and the continuous spectrum, may render it impossible to obtain satisfactory measurements at that point. In order not to have to reject unnecessarily a large number of measurements because the spectrum near the pole was indistinct, we have adopted another method, which, though less rational than the first, is found to give consistent results. From all our measurements we may deduce certain figures for the molecular velocities at different and generally equidistant points on the photographs, and may take the average of all these figures as the mean velocity of the particle. In the following tables, V_1 will always refer to the mean velocity between the pole and a point 2 mm. away from it, while V_2 refers to the average velocity taken for different distances, as just explained. The influence of change of capacity and change in the length of the spark was investigated in the case of zinc, and the following tables exhibit the results. As the zinc lines are sharp near the pole, the first of the above methods of measurement could be applied.

TABLE I.—*Average Velocity* (V_1) *in metres/second of Zinc Molecules.*

Sparking distance. C.m.	Wave-length	Number of jars. 2.	4.	6.
0·51	4925	814	556	416
	4811	1014	668	529
1·03	4925	400	499	415
	4811	501	548	545
1·54	4925	723	1061	435?
	4811	1210	1526	492?

The first striking result to be deduced from the table is the uniformly higher velocity deduced from the double line 4925, as compared with that found when one of the lines of the triplet is measured; for we have ascertained that the two first lines of the triplet are always displaced by the same amount, and the third is so much mixed up with the air lines in its neighborhood that it cannot be measured. It was one of the objects of the investigation to detect, if possible, differences of this kind, which might be accounted for by the fact that the molecules producing different lines of the same spectrum have not necessarily the same mass. We nevertheless hesitate to ascribe the smaller apparent velocity derived from $\lambda = 4925$ to this reason. This line, as has been mentioned, is one component of a double line, and the doublet is not resolved on the photographs taken with the moving film. Near the pole where the light is strong, the edge of the least refrangible component of the doublet would be considered to be the least refrangible edge of the doublet; but near the center of the spark the light is weaker, and

* Abstract of a paper read before the Royal Society, February 2, 1899, and published in Chemical News, London.

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the lines, owing to the motion of the wheel, are drawn out toward the violet. The most intense portion of the image will here be that part where the two lines are superposed, and in wishing to set the cross wire on the edge of the line, we should be tempted to set it on the edge of the most refrangible component. There is reason to believe that this is the cause of the greater deflection of the double line, and the photographs show some signs that if this source of error is eliminated, the molecule giving out the double line moves more quickly than that giving rise to the triplet. We reserve the decision of this point until we have been able to apply greater dispersion.

Comparing the sparks obtained with different capacities, it is found that when the spark gap is small there seems a very curious diminution of velocity as the capacity increases; this is not what should have been expected at first sight, as with the large number of jars we should expect higher temperatures, and therefore greater velocity of diffusion. When the spark gap is 1 cm., the experiments do not reveal any marked change due to capacity. When the gap is increased still further the sparks become very irregular and unsteady, and no certain conclusions can be drawn from our measurements; the numbers marked with a query are specially doubtful. When six jars are used, practically identical numbers are obtained for all sparking distances, but with small capacity the centimeter spark seems to give a lower result than in the two other cases. While we should not like at present to consider this as an established result, the table serves to show that the centimeter spark and the highest capacity used gives the most consistent numbers, and our experiments with other metals were all made under these conditions, except in the case of bismuth, where clearer spectra were obtained with only two jars.

Comparing different metals with each other, we find in the first place that those having comparatively low atomic weights, viz., aluminum and magnesium, have higher molecular velocities. With magnesium the metal vapor is scattered about to such an extent that no measurements could be made, but the average velocity of the aluminum molecule was found to be over three times as great as that of zinc, the numbers not laying any claim to accuracy. Comparing zinc and cadmium with each other, we obtain almost identical numbers, both for the corresponding doublet and triplets.

Bismuth gave remarkable results. In spite of its high atomic weight some of the lines are but little displaced, indicating an average molecular velocity of 1490 meters-second. For other lines the velocity falls down to that of zinc and cadmium, while one line ($\lambda = 3798$) has a still lower velocity.

We have not obtained satisfactory results with mercury; the best were those in which poles used were of zinc or cadmium, which were covered with amalgam. Differences in molecular velocities were obtained for different lines, but the result here is not so certain as with bismuth.

There is obviously no simple law connecting these velocities with the atomic weight.

Dr. Feddersen was led through his researches to the conclusion that the metallic particles after being once torn off from the electrodes by the discharge took no further part in it, were thrown irregularly into the space surrounding the electrodes quite independently of the electric current. Although in some cases, and especially with magnesium poles, there is some evidence that this is partly true, we are led to take the following modified view of the matter.

The initial discharge of the jar takes place through the air; it must do so because there is at first no metallic vapor present. The intense heat generated by the electric current volatilizes the metal, which then begins to diffuse away from the poles; the subsequent oscillations of the discharge take place through the metallic vapors and not through the air. We find confirmation of this view in a striking experiment which is easily repeated. If a coil of wire be inserted in the spark circuit of a Leyden jar, which may be charged either by a Wimshurst machine or an induction coil, tha air lines disappear almost completely, the metallic lines alone remaining; the nitrogen line at 3995 is the only one which seems to remain with undiminished vigor. According to our view we should explain the experiment by saying that the coil which adds self-induction lengthens the duration of the discharge, and allows time for the metallic molecules to diffuse properly into the spark gap. A great part of the energy of the current may then do useful work by heating up the metallic molecules instead of those of air. Mr. Hemsalech is at present engaged in investigating the changes in the metallic spectra which accompany the insertion of self-induction.

The first spark passing through the air will give rise to a sound wave, which, during the complete time of the discharge, will only travel a few millimeters. We may therefore consider that the mass of metallic vapors suddenly set free is driven by its own pressure into the partial vacuum formed by the heated air. It would seem more correct to liken the process to that of a gas under pressure flowing into a vacuum than to that of a pure thermal diffusion. There is not much difference between these views, and we may take it that in our experiment we have approximately measured the velocity of sound in the metallic vapors. This gives a relation between their temperature and density. If we neglect the differences in the rates of specific heat, we find approximately—

$$V = 80\sqrt{T/\rho}$$

where T is the absolute temperature, and ρ the vapor density referred to hydrogen. Thus for cadmium the average molecular velocity found was 560, and substituting $\rho = 56$ we obtain $T = 2700$, which seems a possible value. Hence we conclude that the molecule of cadmium in the spark cannot have a mass which is much smaller than that directly determined near the boiling-point of the metal.

In conclusion we have also taken some photographs in which the slit was directly focused on the sensitive film without the interposition of the film. The photographs show a straight image of the slit followed by a number of curved bands extending from both poles into the spark gap.

The straight image we consider to be the initial discharge through air creating sufficient heat to fill the space with vapor through which the oscillating discharges may then pass. Our experiments point to the fact that the periodic time was rather too small in our experiments to give the best results. The metallic molecule before it has had time to reach through a sufficient distance was possibly affected in its motion by the subsequent oscillation. We hope to remedy this defect by introducing still higher capacities than those used. Our experiments allow us to give the following approximate numerical data. The air rendered luminous by the first discharge remains luminous for a time of about 5×10^{-7} seconds, the metallic vapors then begin to diffuse and reach the center of the spark (the gap being 1 cm. long) in a time which, in the case of cadmium, was about 6×10^{-6} seconds. The periodic time of the oscillations with our six jars and a circuit possessing as little self-induction as possible was about 2×10^{-6} seconds. The metallic vapors remain luminous in the center of the spark for a longer period than near the poles. The duration of the time during which some luminosity can be traced with a discharge from six Leyden jars is about $1{\cdot}5 \times 10^{-4}$ seconds.

THE DISINFECTION OF ROOMS BY MEANS OF FORMIC ALDEHYDE.

WE have already described some apparatus that permit of diffusing small quantities of formic aldehyde through the atmosphere of a room so as to effect the

APPARATUS FOR DISINFECTING ROOMS.

deodorization of it and the suppression of tobacco smoke, as well as the relative sterilization of the air. The small lamps devised for this purpose disengage so much formol that it is prudent not to allow them to operate too long. The mouth becomes dry, and it is preferable to manufacture the gas upon platinum sponge at quite short periods.

The quantity of formol, however, produced by the transformation of methylic alcohol is absolutely inadequate really to disinfect a room that has been contaminated through an infectious disease, such as diphtheria, cholera, smallpox, scarlet fever, etc. M. Guasco, the inventor of the antiseptic lamp which bear his name, has just devised a formic aldehyde generator of great power and small bulk, which is based upon the use of trioxymethylene, a compound that dissociates itself under the action of heat and furnishes formic aldehyde.

Trioxymethylene is a compound of three parts of formic aldehyde $3(CH_2O)$, and it was but natural to think of dissociating it into aldehyde CH_2O; but no one had as yet succeeded in doing this practically because it was necessary to reach the temperature of dissociation with a simple apparatus and to prevent the ignition of the gases produced. M. Guasco has found a solution of the question in his "dissociator," which consists of three elements: (1) of a boiler; (2) of a support; and (3) of a source of heat (an alcohol lamp). The first element alone needs to be described, since the two others are known to every one.

The boiler, which is of copper and cylindrical in form, is provided with an aperture closed by a screw plug and designed to permit of the introduction of the trioxymethylene. In the center there is a chimney designed to serve as a passage for the heat produced by the lamp. In the upper part of this chimney there are two apertures facing one another through which the gas produced by the decomposition of the trioxymethylene escapes in measure as it is formed. The two jets of gas, upon their exit from the boiler, meet in the central chimney, mix with the hot gases from the source of heat (from which they are separated by wire gauze in order to prevent their ignition), and finally become dissociated and completely converted into formic aldehyde.

At the bottom of the boiler there is a layer of fusible metal of slight thickness. When the lamp is lighted, the metal becomes liquid and remains constantly at the same temperature during the entire time of the operation. The trioxymethylene contained in the boiler, which is in contact with the metal in a state of fusion, is decomposed under the influence of the uniform temperature and converted into gas.

In order to disinfect a room thoroughly, the latter is completely emptied, and no one is allowed to enter it. All crevices are closed by pasting paper over the joints of the doors, windows, etc., and the lamp of the dissociator is lighted. Previously to this, the cubage of the room should have been determined, and two grammes of trioxymethylene to the cubic meter should have been put into the boiler. For a disinfection following a very contagious disease, it is well to use four grammes per cubic meter. The door of the room should be closed, too, with strips of paper pasted over the joints, and the apparatus should be left in place for twenty-four hours.

The operation must be the same if it is desired to destroy moths in closets, and, as a general thing, all noxious insects. The disinfection is usually complete, and is performed quite economically, since 90 grammes of formic aldehyde are obtained from 100 of trioxymethylene. The dissociator contains 100 grammes of trioxymethylene, and is but 17 centimeters in height. The chemical costs about four francs per 100 grammes. It is, therefore, possible to disinfect a room quite cheaply.

By reason of its moderate size and the large amount of sterilizing gas that it produces, the apparatus is destined to render great services.

For the above particulars and the illustration we are indebted to La Nature.

HUMAN HAIR INDUSTRY IN FRANCE.

ACCORDING to recent reports of the representatives of the United States government in France, the central departments of Corréze, Creuse, Cher, Allier, Haute Vienne, and Dordogue are frequently visited by hair merchants having orders for human hair from the United States. The dealers in this article say that the inhabitants must be very poor to permit the girls to sell their hair; then there must be a sufficient variety in quality and shade to meet the requirements of the market, and thirdly, there must be a recognized place, where those requiring to sell their hair can find buyers. All these conditions are met in the above mentioned departments. The soil is poor, stony, and hard to cultivate; these low mountains might almost be called the foothills of the Alps. They are for the most part bare, or covered with heather, affording pasture for goats and sheep. Almost all the men are masons, stonecutters, and builders. They leave their homes in the spring for different parts of France to work at their trades, returning when employment is no longer obtainable. The women and girls look after the farm and tend the cattle, goats, and sheep. Their income is very small, and in order to buy a new dress or provide some luxury, the girls consent to sell all but the front part of their hair. Ashamed and humiliated by this act, however, they always wear a coiffe or handkerchief to cover their shorn heads. During the fair of St. Loup and the fair that is held on the last Thursday of August each year, there are regular meeting places where the seller and buyer make their bargains. The average price for a full, long head of hair is about 8s., but an exceptionally fine growth will bring 25s. These sums are counted upon in the annual income of a peasant family.

The hair shipped to New York passes through the hands of commission houses in Paris. Their agents make the purchases in the provinces, the payments being often made part in money and part in dry goods. There is a difference of 1 to 10 between the buying and selling price of the hair. To make up lots of hair, the darker shades of the French are mixed with blond and light hair from Germany and Switzerland. A few ounces of white is often put in a bunch of cheap stuff, to make it sell. In many instances the French and German buyers exchange, so as to supply the markets of the two countries. This industry is increasing annually, and the probabilities are that it will be more extensive in the future than at present.—Journal of the Society of Arts.

DEVICE FOR EMPTYING BOTTLES.

THE apparatus represented in the accompanying figure, from La Vie Scientifique, is designed for the use of lovers of fine wines, who rightly object to drinking such beverages after they have been rendered turbid through shaking the bottle in which they are contained.

After the bottle has been carefully uncorked and its neck has been wiped, the cork is reinserted loosely and the neck is passed through the ring, as shown in the figure, care being taken that the traveler which slides along the rod shall abut against the bottom of the bottle.

The cork is then gently removed and the wineglass is allowed to touch the neck of the bottle, since, without this precaution, some of the liquor might fall upon the table cloth.

After the glass has been filled, the bottle is gently

DEVICE FOR EMPTYING BOTTLES.

raised by pushing it upward with the rim. If the joint upon which the apparatus pivots is too stiff, the screw in the center is loosened; and if the contrary is the case, the screw is tightened.

Consul-General Goodnough, of Shanghai, strongly recommends an American-Chinese exhibition in Shanghai. He says that practically all foreign trade with the middle and north of China goes through Shanghai, and that an exhibition held there will reach the trade of Yang-tse valley and the north.

ENGINEERING NOTES.

In Stanislau oil gas is being a good deal used for incandescent lighting. The gas is used at a pressure of from 1·1 inch to 1·2 inch. When 1·7 cubic feet per hour is used, the Welsbach mantle gives 69¼ candles at first, 65 candles after 120 hours, 48¼ after 500 hours. The fall in lighting power is comparatively slow with oil gas, and the mantles are not so much worn by lighting the gas, for the kind of oil gas is not as explosive as is coal gas. The mantles are found to last from 400 to 600 hours.

The Dismal Swamp Canal has again been put into serviceable condition at a cost of about $1,000,000 and will, according to report, says The Engineering News, be opened to navigation about March 1. The work was done by the Lake Drummond Canal and Water Company, the present owners of the charter. It is 22 miles long, with a depth sufficient for vessels drawing 10 feet. It connects Chesapeake Bay with Albemarle Sound, and affords access to about 2,500 miles of river and bayou navigation in the Carolinas. The original canal was completed in 1882, and cost $1,800,000, slave labor being used in its construction. It was built by the State of Virginia and the national government, each bearing half of the expense.

The "tank" type of ship, we are reminded by a German contemporary, says The Shipping World, is now represented by 180 vessels, having 401,024 gross registered tonnage. From the same source we gather that the first tank steamer, the "Glückauf," appeared in Geestemunde Harbor in July, 1886, so the type has rapidly increased in favor. Of the 180 vessels referred to, no less than 70, of 210,586 tons, are English owned; Germany coming second, with 22 such vessels, aggregating 65,112 tons; Holland third, with 18 vessels, of 37,714 tons; Russia fourth, with 36 vessels, of 30,673 tons; and America fifth, with 10 vessels, and 16,987 tons.

After having been lost for more than fifty years the corner stone of the Baltimore and Ohio Railroad, laid in Baltimore July 4, 1828, was resurrected during August of last year. On the seventieth birthday of the road, last summer, a search was instituted and several surveys were made before the exact location of the relic was found. It was finally found on the old main line, between Mount Clare Junction and Gwynn's Falls, buried about six feet below the surface of the ground. It was in a good state of preservation, the inscriptions being perfect. It is to be lifted from its underground resting place and placed upon a new marble base and surmounted by a marble shaft.

Pictures of two interesting Baltimore and Ohio Railroad buildings have been reproduced in a recent issue of an illustrated magazine. One is the building at Frederick, Md., which has been used since 1831 as a freight station and which is still devoted to that purpose. In the little cupola of the building a bell once hung which was always rung on the arrival of trains from Baltimore when horses were the motive power of the railroad. The other building is the station at Mount Clare, Baltimore, and it is noted as being the location of the first telegraph office in the world. It was from this building that Prof. Morse sent his celebrated message in 1844 to his friends in Washington, 40 miles away.

The Railroad Gazette, in its yearly statistics of the output of locomotives and cars, says that in the last year all the contracting locomotive shops in the United States outside of the railroad shops constructed 1,875 locomotives, as against 1,251 in 1897. This is an increase of 624, or almost 50 per cent. This increase comes within 71 of representing the total output of 1894, and is greater by 218 than the increase of 1895 over 1894, which increase was the largest since 1887. The total output of cars will aggregate 105,158, of which 99,809 are freight, 699 passenger, and 4,650 street cars. Of these 1,663 were for export. The last year was the best for the car building industry since 1890, the record breaking year, when the total number of freight and passenger cars built by contracting firms was 103,000.

An official table recently compiled to show the amount and methods of application of power in the German empire in various industries, including commerce and traffic, horticulture and stock breeding, gives the grand total as 3,421,194 horse power, procured from the following different sources:

Wind	18,364
Water	629,065
Steam	2,715,078
Gas	53,841
Petroleum	7,249
Benzine, gasoline, etc	3,501
Hot air	1,298
Compressed air	11,162

Electricity was employed in 2,245 establishments. In the mining and iron industry, about one-third of the total amount, or 994,050 horse power, was used; in the manufacture of food stuffs, 686,279; in the textile industry, 514,986; in the machine industry, 182,767; and in the chemical industry, 83,164.

"The limestone consumed for fluxing purposes by the blast furnaces in the United States in 1897 in the production of 9,652,680 gross tons of pig iron amounted to 4,247,688 gross tons," according to The Bulletin of the Iron and Steel Association, "of which 3,680,666 tons were consumed by the bituminous coal and coke furnaces in the production of 8,464,692 tons of pig iron; 524,271 tons by the anthracite and mixed anthracite and coke furnaces in the production of 932,777 tons, and 42,751 tons by the charcoal furnaces in the production of 255,211 tons. The average consumption of limestone for the whole country per ton of pig iron produced in 1897 was a little over 0·44 of a ton. The total quantity of limestone similarly consumed in 1898 in the production of 11,773,934 tons of pig iron was 5,275,819 tons, of which 725,729 tons were consumed in producing 1,208,-273 tons of pig iron made with anthracite and mixed anthracite coal and coke; 4,502,309 tons were consumed in producing 10,273,911 tons of pig iron made with bituminous coal and coke, and 47,881 tons were consumed in producing 296,750 tons of pig iron made with charcoal. The average consumption of limestone for the whole country per ton of pig iron made in 1898 was almost the same as in 1897, the figures being 0·448 of a ton, or about 0·008 of a ton more than in 1897."

ELECTRICAL NOTES.

The telephone is very extensively adopted in Japan. Exchanges now exist at Tokyo, Osaka, Kobe, Yokohama and Kioto, that at Tokyo having no less than 4,500 subscribers. Exchanges are shortly to be established at Nagoya and Bakan, while several more are projected. According to The Electrician, a long distance line connects Tokyo and Kobe, a distance of 376 miles, the line communicating at intermediate points with Yokohama, Nagoya, Kito and Osaka.

Science plays a more or less prominent part in the theatrical business of to-day. The Parisian papers, both secular and scientific, have been devoting columns to the appearance in Paris of some American vaudevillists of the gentler sex whose dresses were bedecked with hundreds of minute incandescent lamps. And now it appears that the electric vehicle has found a rôle of its own on the stage. In a play now running in Paris the comedian Baron traverses the boards in an automobile, much to the enjoyment of the audience.—American Electrician.

In some recent experiments on magnet steel it was found that the intensity of residual magnetism of thirty-five specimens, tested in the form of bars, varied from 220 to 560 gausses (lines per square centimeter). In the case of thirteen specimens tested in the form of closed rings the intensity varied from 625 to 860 gausses. Assuming an intensity of 700 for a circuit such as is that of magnetos, the section of steel to produce the same flux must be about thirteen times greater than if a cast iron electromagnet were used, or more than twenty times greater than in the case of a wrought iron electromagnet.—American Electrician.

The Electric Vehicle Company, of New York city, is arranging to place orders for the construction of 200 more cabs, says The Electrical Review. There are to be 25 of the ordinary coupé pattern, 75 hansom cabs, 50 full-extension broughams, seating four persons each, and 50 three-quarter extension broughams, accommodating three persons each, the last two being new styles of vehicles. All are to be delivered by June 1. A new building in Forty-second Street, near Third Avenue, is to be used as a construction and repair shop, and a charging station is to be built downtown and another on the east side, the company to operate 100 vehicles from each station.

The following is a list of plants in which 10,000 volts and over are used, given in the Elec. Tech. At Donaueschingen the voltage is 10,000, and the distance 26 kilometers; at Eichdorf-Gruenberg the power is about 10,000 volts; in France the plant at Ardieres uses 10,500 volts, the distance being 24 kilometers, and at Lavrey 12,000 volts and 30 kilometers; in Switzerland, at Combe-Garrot, 14,000 volts, 20 and 48 kilometers; in Monthoron, 15,000 volts and 60 kilometers; in Canada, at Trento, 10,000 volts and 21 kilometers; at Three Rivers, 12,000 volts at 27 kilometers; Chambly-Montreal, 12,000 volts and 60 kilometers; in Italy, at Paderno, Milan, 14,500 volts and 33 kilometers; in the United States, at San Antonio, 10,000 volts at 24 kilometers; Stockton, 10,000 volts at 16 kilometers; Salt Lake City, 10,000 volts and 22 kilometers; Folsom-Sacramento, 11,000 volts and 38 kilometers; Fresno, 11,000 volts and 56 kilometers; Blue Lakes, 11,000 volts and 63 kilometers; Bakersfield, 11,500 volts at 25 kilometers; Minneapolis, 12,000 volts; and Mechanicsville-Schenectady, 12,000 volts and 39 kilometers.

Messrs. Siemens and Halske have been making a long series of measurements, says The Electrician, upon the electrical resistance of their own workmen and of men employed at the sugar factory at Oschersleben, where recent fatal accidents occurred from low-pressure alternating shocks. It appears that there is absolutely nothing definite about the resistance of the body. Measurements from hand to hand of the men in the sugar factory varied from 900 to 2,000 ohms. Measuring from the hand to earth, the men in each case wearing the wooden shoes customarily worn by German workmen, the resistance varied from 14,000 to over 150,000 ohms. In the evaporating room the resistances lay between 1,700 and 900 ohms. In the boiler house from 1,200 to 3,000 ohms. One man in the repairing shop, who happened to have on new shoes, showed more than 150,000 ohms, the remainder varying from 1,500 to 7,000. All of these measurements go to show that the resistance of the human body is an absolutely meaningless expression, and one that electricians would do well to avoid in the future.

In July, 1898, the Newport News Shipbuilding and Dry Dock Company completed what is perhaps the largest electrically operated jib-crane in the world. The derrick jib is capable of having its outer end raised or lowered, thus giving to the hoisting blocks, which depend vertically from this end, a movement not only of rotation about the center of the derrick, but also of translation in or out from this center. With the outer end of the jib in its lowest position the hoisting blocks will, on rotation of the derrick, describe the circumference of a circle 207 feet diameter; with the jib in its highest position these blocks, on rotation, describe the circumference of another concentric circle 88 feet in diameter, thus permitting the derrick to operate on weights lying anywhere within the circle ring whose maximum and minimum diameters are 207 feet and 88 feet, respectively. The maximum load of 150 tons can be handled only within a ring whose maximum and minimum diameters are 147 and 88 feet respectively, but weights up to 70 tons may be handled throughout the entire field of operation. This feature of varying the radii at which the hoisting blocks can operate constitutes a most important difference between the derrick under discussion and the 130 ton steam crane erected in 1893 on Finnieston Quay, Glasgow. In the Finnieston crane, which at the time of its construction represented the ideas of best English practice, there is no variation in the radius at which the hoisting blocks are carried, and, in consequence, the field of operation becomes narrowed to a single line, the circumference of a circle described by the blocks on revolving the crane. The advantages of the Newport News derrick are obvious. The maximum elevations, above mean high water, for the hoisting hook in the high and low positions of the jib are 118 and 69 feet, respectively, this giving ample clearance vertically for any probable conditions.

SELECTED FORMULÆ.

Silvering Aluminum.—The use of aluminum articles is steadily increasing, owing to the lightness and great durability of this metal. Therefore a process latterly patented in Germany for silver-plating aluminum may be of interest. According to this process, the silvering of aluminum is accomplished, by electrolysis, in a cold bath containing silver nitrate and potassium cyanide in about equal quantities, as well as an alkaline phosphate, preferably ammonium-phosphate. This plating is said to be exceedingly durable, and the method may, therefore, enjoy frequent application.—Technische Berichte.

Desilvering or Dissolving Silver from Silvered Articles.—The following processes from Workshop Receipts are said to dissolve silver without attacking copper, brass or German silver, so as to remove silver from silvered objects, plated ware, etc.:

Cold Bath.—For dissolving silver in the cold the objects are hung in a vessel filled with the following mixture: Sulphuric acid at 66° Baume, 10 parts; nitric acid at 40° Baume, 1 part, in which they remain for a greater or less length of time, according to the thickness of the coat of silver to be dissolved. This liquid, when it does not contain water, dissolves the silver without sensibly corroding copper and its alloys; therefore avoid introducing wet articles into it, and keep the liquid perfectly covered when not in use. As far as practicable, place the articles in the liquid so as not to touch each other, and in a vertical position, so that the silver salt will fall to the bottom. In proportion as the action of the liquor diminishes, pour in small and gradual additions of nitric acid. Dissolving silver in the cold is regular and certain, but slow, especially when the proportion of silver is great. The other more rapid process is then resorted to.

Hot Bath.—Nearly fill a flat pan of enameled cast iron with concentrated sulphuric acid, and heat to a temperature of from 300° to 400° F.; at the moment of using it, pinches of dry powdered saltpeter are thrown into it; then hold the article with copper tongs in the liquid. The silver rapidly dissolves, and the copper or its alloys are not sensibly corroded. According to the rapidity of the solution, more or fewer pinches of saltpeter are added. All the silver has been dissolved when, after rinsing in water and dipping the articles into the cleansing acids, they present no brown or black spots, that is, when they appear like new metals. These two methods are not suitable for removing the silver from wrought and cast iron, zinc or lead; it is preferable to insert the electric current in a cyanide bath or to use mechanical processes. Old desilvering liquors become green after use; to recover the silver they are diluted with four or five times their volume of water, then add hydrochloric acid or common salt. The precipitation is complete when the settled liquor does not become turbid by a new addition of common salt or hydrochloric acid. The resulting chloride of silver is separated from the liquid either by decantation or filtration, and is afterward reduced to the metallic state by fusion with a mixture of sodium and potassium carbonate, or by any one of the many methods in general use.

Ink for Hand Stamps.—Dieterich, in his Pharmaceutische Manual, gives the following formulas for inks in which an insoluble coloring matter is suspended in an oily vehicle, and those made from oil-soluble anilins:

Inks in which the colors are suspended:

ULTRAMARINE BLUE.

(1) Ultramarine in impalpable powder	1 part.
Olive oil	3 "

DARK BLUE.

(2) Ultramarine	1 part.
Paris blue	2 "
Olive oil	17 "

GREEN.

(3) Verdigris, in fine powder	5 parts.
Oleic acid	1 "
Olive oil	5 "

Mix the verdigris and oleic acid, and let stand 15 to 20 minutes, then add oil.

RED.

(4) Vermilion	2 parts.
Olive oil	3 "

BLACK.

(5) Lamp black (gas black)	3 parts.
Olive oil	17 "

These inks should be labeled "Shake before using."

Oil-Soluble Anilin Inks.

RED.

(6) Bordeaux red	15 parts.
Anilin scarlet	15 "
Crude oleic acid	50 "
Castor oil	950 "

BLUE.

(7) Anilin blue	3 parts.
Oleic acid	6 "
Castor oil	94 "

BLUE-BLACK.

(8) Anilin black	5 parts.
Oleic acid	6 "
Castor oil	94 "

GREEN.

(9) Anilin blue	25 parts.
Anilin lemon yellow	15 "
Oleic acid	50 "
Castor oil	950 "

VIOLET.

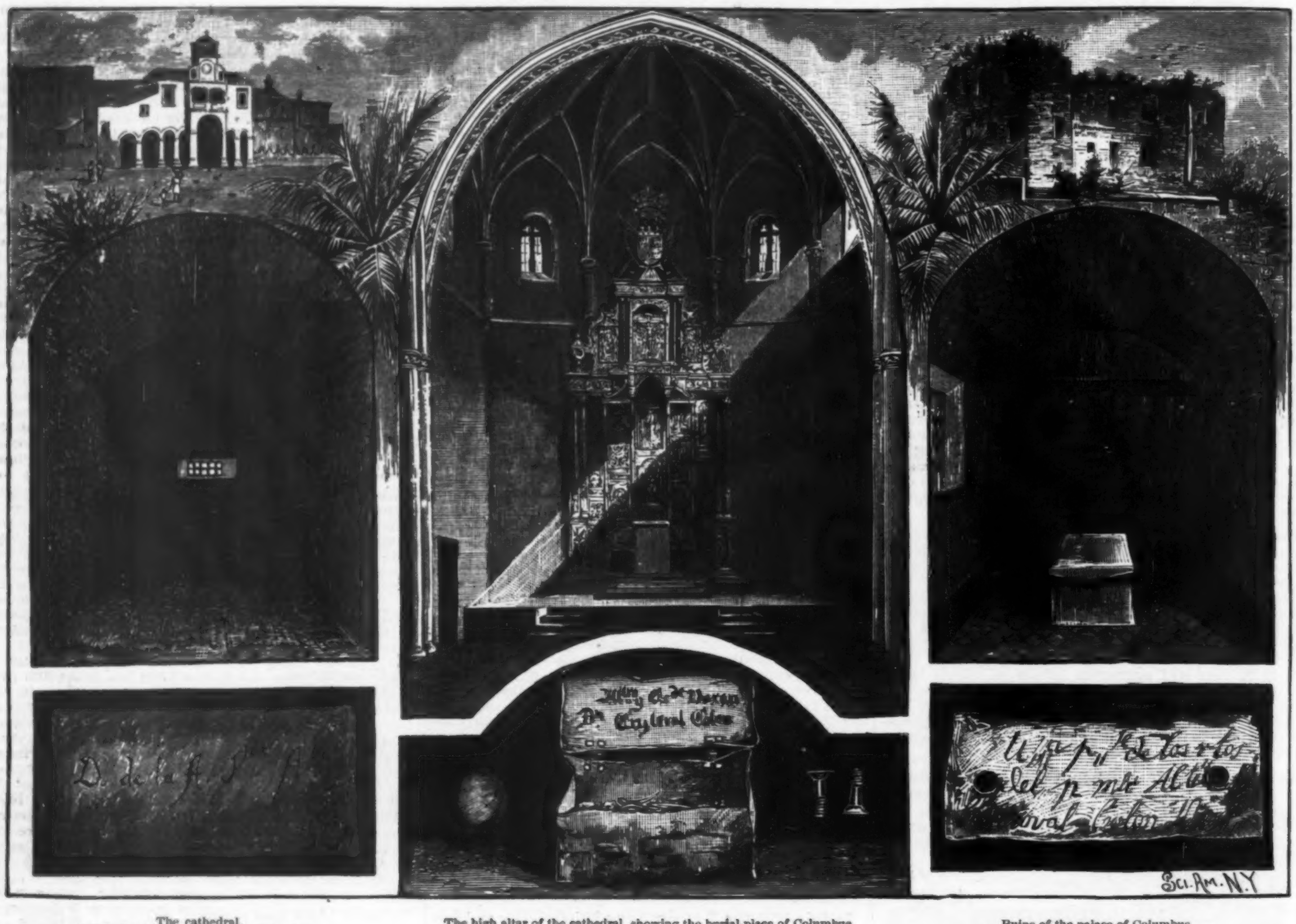
(10) Anilin violet	3 parts.
Oleic acid	5 "
Castor oil	95 "

In preparing these inks rub the anilin (oil soluble) to perfect smoothness in oleic acid; then add the oil, little by little, with constant rubbing. After incorporation of the whole of the oil, heat the mixture under constant stirring to about 45° V. (167° F.)—Pharmaceutical Era.

THE REMOVAL OF THE REMAINS OF COLUMBUS.

ON New Year's Day the Spanish flag was lowered in the capital of Cuba, and the stars and stripes of the victorious republic of the west hoisted in its stead. From that moment Spain ceased to hold possessions in the West Indies. But the descendants of the conquistadors did not wish to leave the mortal remains of the great discoverer, who "once gave a new world to the kingdoms of Castille and Leon," in a land now grown strange to them. They wished to convey these sacred relics to a last resting place in Spanish soil. On the 19th of January, the aviso "Giralda" arrived at Seville with the casket of Columbus, amid the thundering salutes of the batteries on shore. The authorities solemnly received the sarcophagus, and transferred it to the cathedral, where a requiem mass was sung. A few days before, the leaden coffin of the great Genoese had been opened, and only ashes and a few fragments of bone found.

The bones of Columbus seem to have been as restless as his life. On May 21, 1506, the discoverer died at Valladolid, and was buried there in the Franciscan convent. Three years later his body was taken to the Carthusian convent, Santa Maria de las Cuevas, in Seville. In the will which he made just before his death, Columbus expressed a wish to be laid at rest in Española (Haiti), where he had established the first Spanish settlement; but not until four decades later was this wish carried out. Documents which have been preserved prove that the bones of the admiral were deposited in 1549 on the right side of the high altar of the Cathedral of Santo Domingo, in Española. When, by the terms of the treaty of Basel, signed in 1795, the eastern half of the island was ceded to France, a leaden coffin with no mark upon it to indicate whose body it contained was removed from the right side of the altar of Santo Domingo to the Cathedral of Havana, and reinterred on January 19, 1796. On September 10, 1877, while a new floor was being laid in the Cathedral of Santo Domingo, the workmen came across a small chamber between the wall and the vault from which the Spaniards had removed the casket in 1795. In this chamber was found a leaden coffin containing human bones. From the inscriptions upon the coffin, it was evident that the Spaniards in 1795 had not removed the remains of the discoverer, but those of his son Diego, who had also been buried in the old capital of Española. Another investigation, made on January 11, 1891, by the officials of the Dominican Republic in the presence of the foreign consuls, confirmed this view.—Illustrite Zeitung.



The cathedral.
Cell in the citadel occupied by Columbus.
Inscription upon the leaden coffin.

The high altar of the cathedral, showing the burial-place of Columbus.
The leaden coffin opened.

Ruins of the palace of Columbus.
Vault in which the remains will be kept.
Inscription upon a silver plate found in the coffin.

THE REMOVAL OF THE REMAINS OF COLUMBUS FROM SANTO DOMINGO.

A pumping station in the city of London, England, is about to be installed with what will probably be the largest gas engine plant. This plant will consist of 8 double cylinder, horizontal gas engines, 4 of which will be rated at 200 indicated horse power each and the other 4 at 210 indicated horse power each. There will be a number of smaller engines as auxiliaries. The fuel will be coal gas.

EXPERIMENTAL CONTRIBUTIONS TO THE THEORY OF HEREDITY.*

IN this, the first part of a paper on reversion, the two following questions are dealt with, viz.: (1) Is there invariably evidence of reversion? (2) May reversion, when it does occur, result in the complete or all but complete restoration of either comparatively recent or of comparatively remote ancestors? The first question is answered in the negative, but to the second an affirmative answer is given. In support of the view that reversion does not invariably occur, it is pointed out (1) that clear evidence of reversion is rare in the pure-bred offspring of highly prepotent animals, such as Galloway, Aberdeen, Angus, and Shorthorn cattle. And (2) that there is sometimes no evidence of reversion in cross-bred animals. While it is deemed unnecessary to submit evidence of the fact, long recognized by breeders, that the offspring of highly prepotent animals are, as a rule, the image of their parents, it is thought desirable to submit evidence in support of the contention that in cross-bred animals indications of reversion may be wholly wanting. The following experiments bear on this point: (*a*) When a prepotent Galloway bull (which is black and hornless) is crossed with a Highland heifer, the result may be an animal which experts are unable to distinguish from a pure-bred Galloway—there may be neither a trace of the long horned Highland parent nor yet any indication of reversion. (*b*) A peculiarly marked skewbald (bay and white) Iceland pony mare, when mated with a whole colored bay Shetland pony, produced a foal which in color, form, and gait is almost identical with the skewbald dam—on no single point does it suggest the bay Shetland sire. (*c*) A nearly black Shetland mare, when mated with a bay Welsh pony, produced a bay foal which in its make, color, etc., is the image of the sire. (*d*) A pure white fantail pigeon, crossed with a blue pouter hen, yielded a nearly white bird having the form and habits of a pouter, but no suggestion of Columba livia, the supposed ancestor of the numerous varieties of pigeons. (*e*) A white Shorthorn crossed with Aberdeen, Angus, or Galloway cattle results in "blue-grays," which, though more or less intermediate in their characters, rarely afford any evidence of reversion. It thus appears that, notwithstanding the "swamping effects of intercrossing," the offspring of quite distinct varieties sometimes afford no evidence of reversion, and, further, that Galton's law of heredity (which teaches that the intermediate and remote ancestors together contribute one-half of the total heritage of the average offspring) does not appear to hold in the case of highly prepotent animals. In dealing with the second question, experiments are first described in support of the view that there may be complete, or all but complete, reversion to comparatively recent ancestors. (*a*) A blue and white fantail (a cross between a white fantail and a dark blue cross-bred fantail), when mated with a blue fantail, invariably produces pure white fantails, identical, as far as external characters go, with their grandsire. (*b*) A smooth coated white rabbit (a cross between an Angora and a smooth coated white buck), mated with a smooth coated and almost white doe (the granddaughter of a Himalaya rabbit), produced a litter of three, one of which is the image of the mother, one is an Angora like the grandmother, while the third is a Himalaya (with the characteristic black ears and muzzle and dark gray feet and tail) like the great grandmother.

The following experiment supports the view that there may be reversion to intermediate ancestors: A Dalmatian dog crossed with a well bred sable collie produced three pups, which closely resemble young pointers—these pups, with their white ground color and four or five yellowish-brown patches, in all probability reproduce fairly accurately the intermediate ancestors of the Dalmatian sire. This experiment also suggests that if prepotent ancestors occur along the route which any given variety has traveled, reversion may be at any point abruptly arrested. The remaining experiments detailed afford evidence of more or less complete reversion to comparatively remote ancestors: (*a*) An Indian game Dorking cock, crossed with a dark bantam hen, produced, among other birds, a cockerel almost identical with a jungle fowl. It not only resembles Gallus bankiva in form and color, but also in being extremely shy and (unlike the Dorking-like members of the same brood) in its habit of flying away for a considerable distance when suddenly disturbed. (*b*) The zebra horse hybrids hitherto bred are in their markings very unlike their zebra parent. When the sire or dam is a Burchell zebra, the hybrids in the arrangement of their stripes are not unlike the Somali zebra (Equus grevyi), which is in all probability in its decoration the most primitive of all the living zebras. The zebra ♂-horse ♀ hybrids (Zebrules) bred by the author at Penycuik, and the horse ♂-zebra ♀ hybrids (Zebrinnies), bred at Theobald's Park, Herts, by Lady Meux, differ from the Burchell zebra parents, and agree with the Somali zebra in having (1) rounded instead of pointed arches on the forehead; (2) more than twelve cervical stripes; (3) numerous stripes across the loins and croup—instead of five or six broad oblique stripes; and (4) in having the mane extending some distance beyond the withers.

In one of the Penycuik hybrids there are two sets of stripes over the hind quarters. In this hybrid the more pronounced stripes seem to have been inherited through the zebra parent, while the less distinct, which run in a different direction, have in all probability been inherited through the horse parent. This view is supported by the markings, usually found in zebra-ass hybrids, in which the dorsal and shoulder stripes and the bars across the legs are, without doubt, inherited from or through the donkey parent, while the majority of the other markings are probably transmitted by the zebra. (*c*) Mules and hinnies are often more richly striped than their parents; e. g., a hinny recently obtained at Penycuik by crossing a light-gray she ass with a bay Welsh pony has, in addition to dorsal and shoulder stripes, distinct bars across the legs; there are

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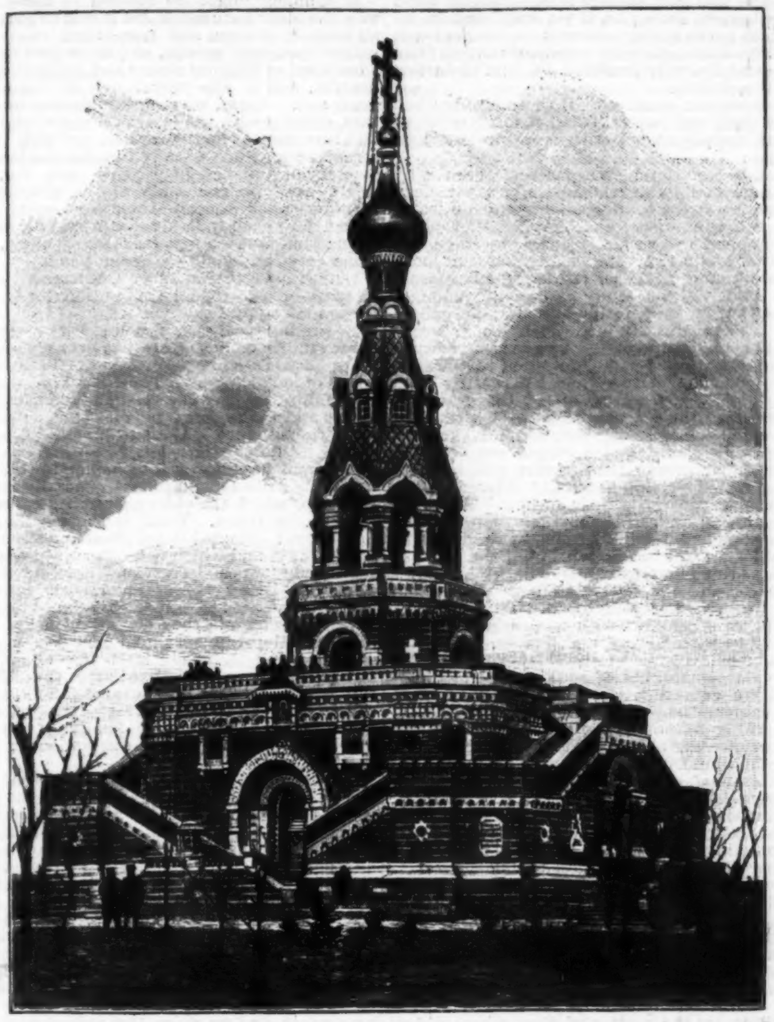
* By Prof. J. C. Ewart, F.R.S. (Communicated to the Royal Society of Edinburgh, December 5, 1898, and published in Nature.)

no leg bars in either of the parents. Moreover, this hinny is of a yellowish brown color and in many ways seems more primitive than either of its parents. (d) The nearest approach to complete reversion has hitherto been obtained by crossing pigeons. Darwin, by crossing a barb-fantail with a barb-spot, produced a bird "which was hardly distinguishable from the wild Shetland species."*

Referring to this experiment, Weismann says that Darwin devoted his attention to the coloration of the species, and failed to state whether there was complete reversion, i. e., a complete agreement in form as well as in color of the barb-fantail-spot with the wild rock pigeon. By way of settling whether in the case of pigeons complete or all but complete reversion occurs, the author first crossed an "owl" with an "archangel" pigeon, and then mated the cross-bred bird with a pure white fantail. The owl-archangel cross had neither the frill, short beak, or short round head of the owl nor yet the crest or bronzed black color of the archangel. The owl-archangel-fantail cross is almost identical in color, size, and form with the Indian wild rock pigeon. The only essential difference is in the tail, for though there are twelve feathers (in the fantail parent there are thirty), the tail is slightly arched; this is the only suggestion of the white fantail sire.

The author believes that the experiments recorded afford substantial support to the reversion hypothesis.

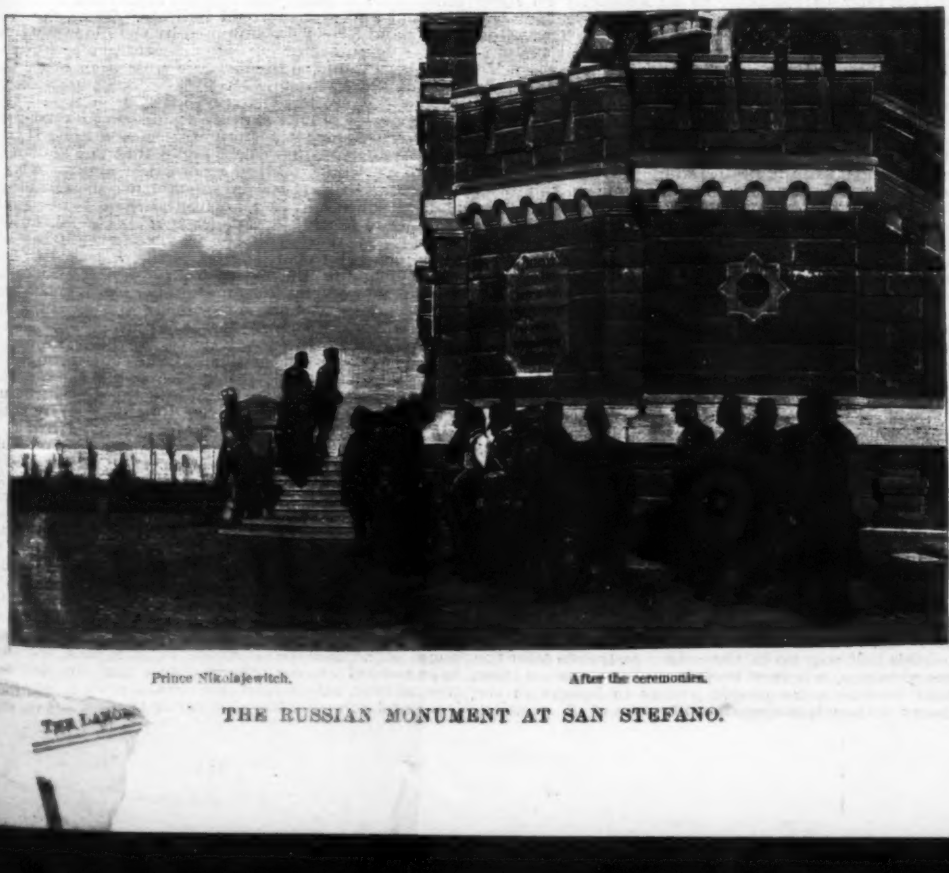
* "Animals and Plants," vol. i., p. 210.



MONUMENT ERECTED TO THE MEMORY OF RUSSIAN SOLDIERS WHO FELL IN THE WAR OF 1878.

THE RUSSIAN MONUMENT AT SAN STEFANO.

THE Russian memorial which rises near San Stefano, on the spot where twenty years ago the treaty of peace between Russia and Turkey was signed, was unveiled on December 18, with appropriate ceremonies. Situated as it is on a hill near the village of Galataria, and surrounded by an eight-foot embrasured wall, the structure from a distance presents the appearance of a fortress. In the interior a chapel has been built, and in a vault therein lie the bones of Russian soldiers who, during the war of 1877–1878, were interred on Turkish battlefields. It has taken years to exhume and collect these bones, and beneath the monument, it is said, lie the remains of 26,000 officers and men. The monument is the work exclusively of Russian artists, and was completed after four years of labor. From the hill on which the structure stands, Constantinople, a portion of the Bosphorus, and the Sea of Marmora can be seen. By order of the Czar, Prince Nikolai Nikolajewitch was present at the ceremonies.—Ueber Land und Meer.



Prince Nikolajewitch. After the ceremonies.

THE RUSSIAN MONUMENT AT SAN STEFANO.

THE NATURAL HISTORY OF CORDIERITE AND ITS ASSOCIATES.*

THE last quarter of the present century has witnessed an extraordinary outburst of petrological activity, due, in a large measure, to the application of precise mineralogical methods to the study of the constituents of rocks. The petrologist, and through him the geologist, owes, therefore, an enormous debt of gratitude to the mineralogist; at the same time, the benefits have not been wholly one-sided. Mineralogy is becoming something more than a mere catalogue of the crystallographic, chemical, and physical characters of museum specimens, and this is largely due to the influence of petrology. It may end in breaking down the artificial systems of classification which are in vogue, and introducing others more in accordance with genetic principles.

ENGINEERING SOCIETY LIBRARY, UNIVERSITY OF MICHIGAN

A good illustration of the advantage of studying minerals from the natural history point of view may be obtained by considering some facts relating to the modes of occurrence and origin of corundum, spinelle, sillimanite and cordierite—four minerals which are so frequently found together that they have been called the "faithful companions." Corundum is crystallized alumina (Al_2O_3), true spinelle is an aluminate of magnesia ($MgO.Al_2O_3$), sillimanite is the silicate of alumina ($Al_2O_3.SiO_2$), and cordierite is a silicate of alumina and magnesia ($2MgO.2Al_2O_3.5SiO_2$). The mutual replacing properties of ferrous oxide and magnesia and of ferric oxide and alumina complicate the composition of the spinelles and cordierite. All the minerals contain alumina, and it is this fact which determines their paragenesis. They occur, usually in combinations of two or more, under the most diverse geological conditions:

1. As the constituents of foliated crystalline rocks of more or less doubtful origin.
2. As the products of contact-metamorphism round plutonic masses.
3. As the constituents of inclusions in plutonic rocks, dikes, lavas and agglomerates.
4. As the direct products of the crystallization of igneous magmas.
5. As the direct products of the crystallization of artificial silicate-magmas.

Cordierite-gneisses are found in many parts of the world in association with biotite-gneisses and other foliated crystalline rocks. Various views have been expressed as to their origin. Some petrologists are content to refer them to the Archæan system; others regard them as due to the contact or thermodynamic metamorphism of ordinary argillaceous sediments; and others as rocks of mixed origin, containing both igneous and sedimentary material. The last view, as applied to certain members of the group but not to all, derives support from the fact that where cordierite-rocks occur as contact products, they always belong to the inner zone, and sometimes give distinct evidence of the intimate intermixture of igneous and sedimentary material.

Cordierite-rocks, often containing sillimanite and a green spinelle, have been recognized, during the progress of the Geological Survey, at many points in the Southern Highlands of Scotland, in the counties of Aberdeen, Banff, Forfar, and Argyle, and quite recently corundum has been detected in some of these; so that the list of the "faithful companions" is now complete so far as Scotland is concerned. It is doubtful at present whether all the Scottish cordierite-rocks are of the same age and mode of origin. Some are contact-rocks, but others may, for the present at least, be more safely classed with the older crystalline-schists. All are undoubtedly the result of the metamorphism of highly aluminous rocks.

A very interesting case of the occurrence of all four minerals in rocks due to contact action has been described by Salomon. It occurs in the southern part of the Eastern Alps round the great mass of tonalite, of which Monte Adamello forms the culminating point.

Inclusions, derived either from a contact-zone or from the crystalline-schist formation, containing two or more of the minerals in question, have been observed in igneous rocks occurring under the most diverse conditions in many parts of the world. They have been found, for example, in the tonalite of Monte Aviolo; in the kersantite-dike of Michaelstein in the Hartz; in the andesitic lavas of the Eifel, the Siebengebirge and the southeast of Spain; and, finally, among the ejected blocks of the Laacher See and Asama Yama in Japan. There is evidence, moreover, that in most of these cases the minerals, or some of them, occur not only as constituents of the inclusions, but also as the direct products of crystallization from the igneous magmas. Thus in the mica-andesite of Hoyazo (Cabo di Gata) cordierite occurs in two forms: 1, as irregularly bounded grains up to the size of a hazel nut, and 2, as sharply defined idiomorphic crystals in a glassy base. The former are inclusions, the latter are crystals which have separated from the magma. Rock fragments, consisting very largely of a cordierite-gneiss from which the isolated grains of cordierite have been derived, are also very common in this andesite. Osann, who has described this very interesting case, points out that the abundance of indigenous cordierite, coupled with the presence of numerous inclusions of cordierite, and cordierite-gneiss, points to the conclusion that portions of the foreign rock have been dissolved, and that a magma of exceptional composition has thus been formed, out of which cordierite has crystallized. Many other cases are known in which the solution of foreign aluminous material has so modified a magma that

*Abstract of the presidential address delivered to the Geologists' Association, by J. J. H. Teall, F.R.S., on February 3.

members of the group under consideration have crystallized out of it. Moreover, it is not necessary that the minerals should be present in the foreign material. It is sufficient that the necessary chemical constituents should be present. Thus a basalt from Kölnitz, in Carinthia, has involved fragments of an argillaceous rock, and partially dissolved them. The normal basalt is holocrystalline, but in the neighborhood of the inclusions it becomes glassy, and crystals of spinelle and cordierite, which are absent, both from the basalt and the inclusion, occur. The partial solution of the fragments evidently modified the composition of the basalt, so that it cooled as a glass after cordierite and spinelle had separated out. It is interesting to note, in passing, that the addition of alumina to the basaltic magma has tended to prevent crystallization. This effect of alumina is well known to glassmakers.

The formation of corundum in an igneous rock as the consequence of the solution of argillaceous material is well illustrated by the case described by Prof. Busz. The mineral occurs round inclusions of clay slate in a felsite from South Brent. Many cases of the presence of corundum in igneous rocks under conditions which prove that it must have crystallized out of the magma are now well known; and among the most interesting are those recently found in Hastings County, Canada, where the mineral occurs in dikes of sienite. In these, however, there appears to be no evidence that the excess of alumina is due to the solution of argillaceous rocks.

The remarkable synthetic experiments of Dr. Morosewicz give a complete and satisfactory account of the chemical and physical conditions under which corundum, spinelle, sillimanite, and cordierite separate out of alumo-silicate magmas; and, therefore, of many of the natural occurrences above referred to. Alumina is soluble in magmas agreeing in composition with albite, nepheline and anorthite, or with mixtures of these, and crystallizes out as corundum on prolonged cooling at high temperatures. If both silica and alumina are present in excess of that necessary to form feldspar, sillimanite is formed until the excess of silica is used up, and then the remaining excess of alumina crystallizes out as corundum. The presence of magnesia determines the formation of spinelle, or of cordierite, or of both, according to the excess of alumina and silica above that necessary to form feldspar with the soda, potash, and lime present. All these phenomena may be verified within the range of temperature in a Siemens furnace, such as that used in glass works. The minerals obtained are in every way similar, except as regards size, to those which occur in nature.

It thus appears that the "faithful companions" may be formed either by the metamorphism of sedimentary deposits or as the result of the crystallization of igneous magmas of exceptional composition. In many cases, if not in all, the presence of these minerals in igneous rocks is the result of the solution of argillaceous material. It seems fair to conclude, from their general absence from masses of granite and other igneous rocks, that the absorption of argillaceous sediments has not taken place on any large scale. But in drawing this inference caution is necessary, because, under plutonic conditions, the presence of water may lead to the formation of micas instead of them. Fused biotite gives rise to spinelle, and fused muscovite to sillimanite and corundum.—Nature.

CONCERNING THE THEORY OF EVOLUTION.*

It is both proper and common nowadays to remark that we live in an age of change. When people say this they generally mean that we have quit walking and riding horseback, and go about by electricity and bicycles, and expect presently to be sailing in air ships. Every one is impressed with the material advances that science is making; but when I say we live in an age of change, I do not refer to trolley cars, telephones, vitascopes, or anti-toxin for diphtheria, but to changes which are not so striking, yet on that account none the less real and important. I mean the changes in men's minds under the influence of scientific thought and investigation. The material achievements—discoveries in light and electricity—are the most striking and attract the most attention; but are they more important than the effect of science on men's theories and beliefs? Which is of more consequence—what a man is, his own thoughts, or the way he is carried about? I submit it to you as quiet, thoughtful people, if the life of a man's mind, bound up as it is with his immortal spirit, is not of infinitely more consequence than any material service which science can render. A good many people are afraid of the activity and spread of scientific thought, thinking it will take away belief in the supernatural, and so rob life of the deepest interest. Do they forget that God made the world? If the Bible came from Him, is it any the less true that the hills and the trees came from Him? Is the truth we find in them any less sacred than the truth we find in the Book? Truth is truth wherever it is found; and it will never conflict with itself. If God has given us intellects and laid before us the volume of the natural world, dare we turn away and refuse to read therein? Knowledge about the world is knowledge of its Creator. All truth is God's truth. Can a man be honest with his own intellect and shut his eyes to any fact? Is it not your verdict that we would better make up our minds to inquire into the truth of everything, making sure that a faith that is well founded will not be upset by anything that is true? Every fact is sacred. Our interpretation of facts may differ, but we dare not refuse to look at them. "Prove all things. Hold fast that which is good."

With this preface, we will look at this thought change. The process of change has been going on for several centuries, but it has never gone so rapidly as during the last thirty years. During this last generation the thought activity of science has centered around one theory—the theory of organic evolution. This theory Charles R. Darwin hid in the meal of biological facts, and it has gone on working until it bids fair to leaven the whole lump of human understanding. If we may trust some of those who are set to enlighten the people, "evolution" means merely that if the folks of the Philadelphia assembly who delight in tracing their ancestry would go back far enough, they would come to a chimpanzee as the eldest patriarch; or, if we may depend upon others, evolution signifies everything that is, has arisen from the nothing that was; still others tell us that evolution teaches that in times past the eggs of crocodiles hatched into birds, and the eggs of birds into—rabbits mayhap; or that evolution means that animals sprang from plants much in the same way as Topsy springs from a cabbage head in the magic lantern show; or, if we may confide, indeed, in certain persons who are sent to be shepherds unto us, evolution is a poisonous creed, emanating from the Evil One and specially invented by him to darken the light of the church.

Evolution does not mean any of these things; but question any class, and you will find a mixture of all these notions, happily mixed with more or less right comprehension.

What, then, is evolution? We can best get at it by a study of some one living thing—let us say a bean plant. If you take up a bean seed, you will notice on the outside is a thin husk; and, tearing that away and looking at the parts within, you see two large, flat pad-like bodies, and beside that something that looks like a short stalk, and, again, something which appears like a little bud. If you study it carefully enough, you will see that what is inside the bean is really a little plant. Where did the little plant come from? That seems like an idle question. A bean is not formed in the ground, nor does it come down out of the sky; it came but from one source—from the mother bean plant. So do all seeds and so do all living things. Here then we learn the general principle of biogenesis—the origin of all things living from a living ancestor.

If the bean were placed under proper conditions of nourishment, under proper temperature and supplies of moisture, it would develop gradually different parts, which, in time, would show their nature. The bean will burst the husk; and, from the time of its coming forth, the various parts will become more different. The first real leaves will be different from the pad-like bodies; and, as the plant grows, it will get a greater number of parts, and these will be more unlike each other, until we have the long bean, twining around whatever support it can find, with tendrils and various leaves, and, later, with flowers, and, finally, with fruit again; so the whole course of the story has been not only one of enlargement, but of acquirement of different parts. Here we have a second principle, common to all living things—the principle of differentiation.

The next thing to notice is that this bean plant, after it is grown, bears a striking resemblance to one thing only—the kind from which it came. It does not grow into this, that, or the other. The offspring is like the parent. Here we have the law of heredity, every offspring similar to its parent.

But in the last place, if you will look at the new bean plant carefully, you will see that it is not exactly like its mother; and if you plant all the beans from a pod in the same soil and have them grow up under the same conditions of nourishment, they would not be exactly alike; even if you compare all the beans in a gardener's patch, you would find no two just alike. Here we have the four principles: biogenesis, differentiation, heredity, variation.

In studying the bean so attentively, one could not have failed to ask the question, "Where did beans come from?" or, for the matter of that, where did all plants and animals come from? There are only two possible answers; for no one can say that species have been eternal, or that they have made themselves. The first answer is that the Creator made the first ones of each kind directly. This view is called "special creation." The only other possible answer is that of evolution; and this answer means that the first bean arose as beans now do; that the plants and animals now living have gradually descended from others that have lived in times past; that living nature has come up like a great tree, with branches pushing further and further apart and becoming continually more different from each other; that the great kingdom of life has unfolded from a simple beginning; and that this simple beginning, the ancestors of all we now know, came from—we know not what. I repeat, we know not what.

According to the principle that we should prove all things, let us take the theory of evolution on trial and see what evidence we can find of its truth or error. I need not refer to the Bible as an authority on these things. I think every one here will agree that the Bible is not sent to teach any scientific theory. God never tells us a truth that we can find out for ourselves, and when He was revealing Himself to man, He did not, in the same breath, tell him how He made beans.

Any one familiar with nature would be likely to object to evolution, because it is contrary to what we see. There are many different kinds of living things, each reproducing faithfully its own kind; so that the plants we find with the Egyptian mummies and in the Swiss lake dwellings are the same as we find to-day. The consideration of these facts led the older naturalists to deny emphatically the possibility of evolution. I know you are thinking that new species might be produced by crossing, but the fact of the matter is, that most species will not cross; that is, if you place pollen from a bean flower on the stigma of a pea flower, there will be no result, and the same is true in most other kinds of plants and animals. In the exceptional cases the offspring is called a hybrid; but such hybrids are generally incapable of reproducing their kind and die without offspring, as, for instance, the common mule. You will see at once that if hybrids are rare and then generally sterile, the origin of species by crossing is not likely. I should say that there are some fertile hybrids, as, for instance, among pitcher plants, willows, and orchids, and even among the higher animals; and here new species are produced by crossing; but such exceptional cases are of little account when we are considering an alleged universal process.

An apparent objection to the theory of evolution is lack of sufficient cause. Is it not asking a good deal that we should believe in a process of which no reasonable explanation can be given? Another objection is that no straightforward record of it can be found in the rocks. The first undoubted fossils we know of are animals half way up in the scale; and, even after the record begins, it is very broken. I lay stress on these facts because some people profess to believe in the theory without knowing the difficulties of the position.

But let us take a survey of all that is known of plants and animals and see if any further light can be got from the facts. The evidence can be most conveniently grouped under three heads: I. From the forms and structures of living things, or Morphology. II. From their distribution or occurrence. III. From direct experiment.

Morphology might be studied in three ways. The way the older naturalists did it was to gather together all manner of forms and trace their resemblances and gather them into groups, and these into larger groups. That kind of study of plants and animals we call classification, and it was very much in vogue a hundred years ago. Again, we might go deeper into the structure, dealing with the internal organs and their parts and how they are put together, and seek out their resemblances. Such a study is called anatomy; and that was much pursued fifty years ago. Or, again, we might take up the study of the structure from the standpoint of genesis—trace how each organ came about, how each individual acquired its structure and form; that study is known as embryology, and has become very fashionable in recent years.

Likewise we might study Occurrence in two ways: in space—geographical distribution; or in time—as recorded in the rocks.

Beginning with classification, let us see which way these studies point. Have you ever noticed how much many plants are like each other? Take the different kinds of lady slippers. There is a kind that grows up tall and bears yellow flowers, and another has but two leaves and bears large purple flowers; yet there is a great resemblance. Among animals, although no one would mistake a tiger for a panther, they are much alike; and a child would be inclined to call them "big kitties." Animals and plants generally are assembled in groups which the older naturalists called genera, or families, or tribes. What is the meaning of this resemblance? Every kind of plant and animal has others much like it and which the older naturalists called its relations. "Special creation" answers that it is because all living things have been formed by one Creator, and are alike just as the buildings planned by one architect would be; evolution insists that the so-called relationship is real and that flowers are alike and panthers and tigers are alike just as children of the same family are alike; that in fact the different lady's slippers are children of the same family, and the panther and tiger and all the rest of the catlike animals are children of the same family. I do not believe any one could give a third answer, so we must choose between these two.

Looking a little further, we will see that these tribes can be united into larger groups and that in reality all sorts of plants and animals are constructed on a few great types. For instance, a number of animals are constructed on the vertebrate or back-bone type and another great number on the starfish type; twelve or fifteen such types would include all the plants and animals we know of. Imagine a picture of a tree, branching low down into two trunks, and as these come up, subdividing into several branches. Suppose we take all the vertebrated animals to be represented by one of these principal branches and the starfish-like animals to be represented by another, and consider the whole tree, branching at its base, to represent, in its two sides, the animal and plant kingdoms. Of course, the vertebrated type would break up into four or five divisions—into mammals, birds, and reptiles and fishes; but the scheme would still fit very well. Then to express the carnivorous, herbivorous, and gnawing animals, you only need to subdivide one of these branches. Some time try to make any other sort of diagram to express the truth. This diagram, for instance, shows that fishes are more like birds than they are like starfish. Nobody doubts that fishes and birds both have backbones and starfish have not. By varying these branches you could represent every living thing and represent its correct relationship to everything else. If you think the diagram is without meaning, try to make another one that will fit the case. You could not satisfactorily arrange them as in a chain; nor as areas in a map. Does the fact that the classification of living creatures takes the form of a family tree seem to you to have any significance?

Let us look now at the general facts of anatomy and see what meaning may be got from them. Plants and animals are in reality much more alike than even their external appearance would indicate. Thus, flowering plants and ferns were supposed by the older botanists to be constructed on entirely different plans; but they have been found to so much resemble each other that the same terms are now used for designating the reproductive organs of the two divisions. It is a fact that whole groups of creatures are builded on the same plan, however different their appearance and condition of life may be. No one could argue that the prehensile arm of a monkey, the foreleg of a deer and the wing of a sparrow bore any special resemblance to each other; and yet you would find about the same bones joined together in nearly the same way; and, also, in the foreleg of the turtle and of the frog you would find the same plan still to persist. Or, in the skeleton of a bear you will find in the neck seven vertebræ, and in the neck of the squirrel the same number; even in the long-necked giraffe we find no new ones; and the almost obliterated neck of the whale still has seven. So, beneath the greatest apparent diversity, we find the deeper similarity. This law of likeness runs all through the living world. I think if we looked awhile the question would gather great force. "Why is the same structure retained when the needs are so different? Why is the wing of a sparrow like the leg of a deer?" Now, as in the case of classification, only two answers are possible. "Special creation" assumes that the Creator had in mind a certain structure and chose to limit Himself to it in making very different creatures. Why He who has infinite resources should do this is not explained. Evolution teaches that these creatures are so much alike because they are blood relations—that they received their structure from a common parentage and it has only become modified to suit different needs.

Before you decide which is right, I must point out something further, that structures are retained in many plants and animals which are useless. In the reptile house at the Zoological Garden, Philadelphia, you may have noticed (among other animals that are not reptiles) a long, salamander-like creature with ... legs; and you must have observed th... there are

* A lecture delivered at the Temple College, Philadelphia, February 3, 1899, by Charles H. Shaw, M.A., of the college faculty. Revised by the author especially for the Scientific American Supplement.

weak to carry around the heavy body. Then why does the Amphiurna have legs? Or, if you look at the python when he is coiled so that you can see the posterior portion of the body, you will see about the place where there ought to be legs that there are indeed places that suggest legs; and in the skeleton of the python you will find a rudimentary pelvic girdle at that point; and, therefore, there is all provision for legs, but no legs of any account. A few years ago, in dissecting a whale, some one found deep in the muscles of the posterior portion of the body, where legs might be, two or three small bones corresponding in position and structure to the bones of the pelvic girdle. What use these bones have I must leave for you to decide. These illustrations are by no means isolated; our own bodies are full of similar ones. How nearly wisdom teeth deserve to be classed here perhaps some present could tell us.

After considering all these facts, which is more probable—that the Creator had one plan in mind and carried it out to the degree of giving many animals useless organs; or, that these things represent inherited structures which are in process of becoming lost because the creature has adopted a mode of life for which they are no longer needed?

Turning to the last of the morphological studies, in seeking to find out the origin of living things, would it not be most natural to study how they come into existence now—that is, embryology? In watching the development of the eggs of plants and animals some surprising things have been observed. You know the embryos of all things come from a single cell—a fertilized egg. If you were to examine the embryos of the young of one type, you would find their resemblance to be nothing short of astonishing. If you look at a set of pictures illustrating embryos at an early stage, you will notice this remarkable likeness.

Moreover, a partly developed animal is likely to have a structure which does not belong to its kind but rather to some lower animal, so that it has long been known that each individual in its own personal development repeats, in a rude way, many of the structures of the animals that are below it. It is a fact that when Nature sets about building a robin, she commences by surveying an outline for a fish, then gradually changes that by forming something more like a reptile than anything else, and only later modifies that into a bird and finally into a robin. Fishes breathe by gills; and the arrangement of the blood vessels in connection with this is very characteristic. If you should examine a robin embryo after the egg has been sat upon two or three days, you would find gill-clefts and the blood-system of the fish; and robins are not different from other creatures in this respect; for everywhere we find organisms passing through stages of the forms beneath them. This is true to so remarkable a degree that competent naturalists have been deceived into thinking that the young of a higher group of salamander (the axolotl) was the adult stage of the group below; the fact was, that only the young of this group had been known and had been kept from developing by the cold mountain climate of its home. What is the meaning of such facts as these? Those who defend the theory of Special Creation say that the organs of the embryos take these forms because they are best adapted to the needs of the embryos; but this is quickly exploded because many of these embryonic organs could have no use. A calf has teeth in the upper jaw that never come through to the gums; an embryo horse has five toes like other animals; but perhaps the most impressive fact is that the gill-slits are found in the embryos of all vertebrates up to man himself. Whither do these facts point? Are we to believe that all these strange things were done for some purpose we cannot imagine, or accept the answer of evolution and regard them as the consequence and evidence of the relation of things living? The only other view besides evolution which can account for this likeness is the unity of plan in the mind of God and the evolution of an idea; and I confess that I cannot see how the view of the evolution of an idea gives a rational explanation of the facts. He who adopts that view must believe that the Creator carried over into newer structures the useless features of His last production; it assumes that, with infinite resources, He adhered to one plan and made a whale and an armadillo and a man alike simply because He had one type in mind. Does not the view of unity of type in the mind of the Creator, and the evolution of an idea, shake and totter by the very weight of its own implications? But it is the only escape from the evolutionary hypothesis.

Passing from the first head, let us take up the evidence under the second—Occurrence. There are two kinds of Occurrence—in space and in time. The argument from occurrence in space can be expressed in one sentence. Nearness of resemblance is connected with nearness of distribution. That is, creatures are related to one another, not according to the conditions under which they are found, but according to the barriers to their migration, such as a wall of mountain range or a deep and ancient channel of the sea. This is hard to present in a few words; but, to my mind, it is the most conclusive of all arguments for the theory of descent. On the theory of special creation, we would expect that the forms of life would be created each one for its own environment, and that in similar places we should find related creatures. That is precisely what we do not find. Take, for instance, the conditions of life on the east coast on the Atlantic side of South America; they are very similar to those on the Pacific side; but we find different orders of fishes and mollusks and seaweeds. If species are gradually modified, it is just what we should expect to see; as the two shores have long been separated by a barrier that no fish or seaweed could cross.

The conditions found on islands are significant; for the difference between the inhabitants of an island and of the mainland is in direct proportion to the obstacles to migration. Madagascar, cut off by a deep and ancient arm of the sea from Africa, has an entirely different fauna and flora; while the British Isles, separated by a comparatively recent channel, have a fauna and flora nearly identical with that of Europe. The Galapagos Islands, off South America, are occupied by fauna showing evidently the stamp of South American peculiarities; though few of the species are exactly the same. So it looks just as if colonists from the mainland had occasionally got across, and, becoming gradually modified, still showed plainly their kinship with the ones on the continent. It was this condition of affairs on the Galapagos that first suggested the idea of evolution to Mr. Darwin, and set working in his mind the great theory.

When we come to volcanic islands which lie far out at sea, we find two very noteworthy facts. In the first place we find few, if any, species which occur anywhere else; and such as are found are always somewhat like those on the continent from which stragglers might have come, just as if rare waifs had been borne thither and, becoming modified through long periods of time, only dimly betrayed their ancestry. It cannot be urged that these peculiar island species are specially fitted to their environment, because they are generally quickly driven out by the forms man has introduced from the continents. In the second place animals and plants that could never have been blown or floated long distances are never found on islands far out at sea. Large quadrupeds and toads and frogs that are killed by sea water do not occur there. If Special Creation is true, why were creatures that could not have traveled far never created on Oceanic islands? Why is the cocoanut palm, whose thick-wrapped seeds float for weeks in sea amber unharmed, the only palm found on the far away coral islands and on both continents?

Of course the believer in Special Creation must regard species as fixed units; and anything that would show that species are changeable would take away the corner stone of the doctrine. I think I can mention a case that almost does that.

Several years ago I was exploring some of the caves of Southern Indiana. One of these was called Crawfish Cave and inhabited by the animal we call the crayfish. Over in Austria in Europe there are certain limestone caves, also inhabited by crayfish. In temperature and composition of the water and all the conditions they are just as nearly as possible like the caves in Indiana as any two sets of environment could be; yet the crayfish found in Crawfish Cave are similar to those found in the hills around, but of a different species; while the crayfish found in the Austrian caves resemble those living in the streams of the hills around there. Does not this border on a demonstration of the origin of each of these underground species by divergent modification from those living on the outside? Has the Creator placed all things then as if plants and animals came by descent to make us believe a lie? Does not the denial of evolution lead to worse difficulties?

Turn from occurrence in space to occurrence in time, and consider the facts of paleontology. The statement of the argument here is—"Nearness of resemblance is connected with nearness in distribution; and there has been a gradual unfolding as time went on." But it is asked, "If there has been this gradual unfolding, where are the missing links?" Why don't we know more about them than we do?—for it is a fact that missing links are rare enough to be prized when found. There might be many reasons why there are not missing links; but it takes a great deal of negative evidence to balance a little positive evidence; and the fact that missing links are found outweighs all the arguments that more are not found. One reason why missing links are few is the conditions under which fossils are laid down. No fossils are preserved except under very peculiar conditions. An animal that dies in the field will not be preserved. A fossil will only be preserved when the creature sinks into a boggy place and so is half petrified and preserved, or else dies in some arm of the sea or along some coast where silt is being continually deposited. The only chance for a land animal or plant to leave its fossil is either to sink in a bog or else fall in a river and be floated to a place where it can be covered with silt. How many animals that lived in this country a hundred years before the white man came here met with such accidents and were so preserved, and how many that were preserved would ever be found? Is it not a wonder that we find as many missing links as we do?

If geographical distribution in some places is a demonstration of the origin of species by descent, fossil beds in some places are a record of it. In Wurtemberg there are some old lake deposits that run through a long time without a break, and abundantly containing fossils of a genus of mollusks called Planorbis. In the lower beds of this series remains of this mollusk are so much alike that any one would recognize them as the same species; further up they become somewhat different; and still further up they gradually break into kinds so diverse that no one would rank them as the same.

Before we leave occurrence in time, I may ask you to notice that, whenever we can trace backward a series like that of Planorbis, or the well known one of the horse, we find it to be a line converging with other lines. If lines continually converge, they must come together somewhere.

The facts under the third head—experiment—could be spoken of so much better fifty years hence, that I think we had better leave it for the present.

Aside from all the facts, an à priori consideration of considerable weight is that Nature is continuous, and seems to work by orderly processes. Things come to pass now as a succession of related events; and, reasoning from what we see to what we have not seen, it becomes strongly probable that they have always gone so.

Thus the evidence can be outlined; but, in a discussion like this, its weight is not felt. The evidence is cumulative, and comes slowly; but it does accumulate, and it has accumulated in the minds of men until those who reject the theory of evolution are scarcely to be numbered among workers in modern biology.

So far we have dealt with the fact of evolution. At once comes the question, How did all this come about? and the partial answer of this question was, perhaps, Darwin's greatest achievement. Fifty years before Darwin, Lamarck had put forward the theory of evolution, and assigned as its cause the effects of use and disuse of organs and the direct influence of environment. According to Lamarck, the Polar bear obtained his long, heavy hair by living in a climate that required it; the giraffe developed his long neck by continually stretching after high foliage; and, in a like manner, the kangaroo acquired his great hind legs by much jumping. But it was perceived that these causes were in nowise sufficient to account for the process, and Lamarck's evidence of the fact of it also being scanty, his work, after much ridicule, passed into oblivion. That was at the beginning of the present century.

In 1859 Charles R. Darwin, in his epoch-making book, the "Origin of Species," brought out the theory of evolution again, this time supported by abundant evidence, and pointing out a most powerful and hitherto unsuspected cause—namely, natural selection, or the survival of the fittest. Many persons, even those who have attempted to criticise Mr. Darwin and his works, have no notion of the meaning of the expression, or idea of the operation of the great cause which he called by this name.

In the first place, note the fact that all plants and animals produce many offspring—from the termite and the codfish, which bring forth their millions, to the comparatively slowly multiplying eagle and elephant, all organisms do multiply; yet, on the whole, the number of inhabitants remaining about the same, only two offspring from each pair can survive. By far the larger number of the young plants and animals must die for mere lack of space and food. Of the ten thousand seeds that a thistle sends floating forth, only a few can possibly survive. A pair of rats, if all their offspring lived, would in two years amount to a million. It is easy to see, therefore, that with the earth being continually overstocked, there must be a great struggle for existence, in which the larger portion of combatants must perish. Now from the bean we learned the general laws of heredity and variation—that each offspring inherits the peculiarities of its parents, and that no two individuals are exactly alike. Among myriad offspring, there may be and often must be some who, by their individual peculiarities, are better able than others to live; and, since the race will be to the swift and the battle to the strong, these will be likely to live and their mates perish; and then the law of heredity, stepping in, will give to their offspring the character which enabled them to win, and the race will be modified in the direction of the winning characteristic.

In the case of the giraffe, living as it does in a country full of herbivorous animals, and where foliage for their food is often at a premium, it is evidently an advantage to have a long neck. Among the antelopes, from which the giraffes sprung, there would certainly be some with longer necks than others; and these would be able to reach a line a little higher than their mates, and so find food in time of drouth when all on a lower level was gone. Thus the short-necked individuals would perish, the ones with necks a little longer survive, and this being kept up, the species would become longer and longer necked, till the limit of usefulness would be reached; and then, of course, all development in that direction would cease. This, then, is natural selection. Not, as many ignorantly suppose, that Nature is a conscious something, which chooses, but a mechanical necessity arising out of the conditions of the case.

The battle for life is a very real one. The struggle for existence is not a figure of speech. In sentient nature, tooth and claw, speed and cunning, are desperately applied in the unending and bloody strife. Most of the combatants must perish. The doom of early death is written and sealed for ninety-nine of every hundred creatures that come into the world. Every wolf in a pack is strong, because all the weak ones have perished, and the members of the pack are the survivors of a much larger number of cubs. The vastly greater number of creatures that begin life are either starved to death or killed outright by their enemies. Do you see how quickly any variation of slight advantage to its possessor would be laid hold of and preserved?

Natural selection is by far the most powerful factor of evolution; but there are other factors, such as use and disuse of organs, sexual selection, and perhaps others of which we know nothing.

Naturalists are divided into several schools along this line. There is the Darwinian school, which follows Darwin exactly, saying that natural selection is the principal factor, and the others are subordinate. Then there is the Neo-Darwinian school, headed by Wallace and Ray Lancaster and Weissman, holding that natural selection is the only factor, and that nothing else has had anything to do with it. And then the Neo-Lamarckian school, founded by our own Prof. Cope, which holds that natural selection is a subordinate factor, and the most important are use and disuse of organs and environment.

Do not suppose the theory of evolution has anything to do with the origin of life. We are as summer butterflies flying through a wood and seeing all kinds of trees, from the great pillars down to young seedlings, and saying to themselves "Ah! we see; we understand; all these trees have grown from tiny seedlings." Would they know how the seedling got its start? Neither have we any notion of how life began. We only say we think life grew, just as the butterflies of summer days might say, "We think the trees grew."

But, it will be urged, does not evolution conflict with our ideas of God as creator of the universe? At first sight it would seem to. But I think the principal difficulty arises from failing to perceive that evolution is not a cause, only a process, that is to say, it is a natural law. The law of gravitation does not cause a stone to fall to the ground: it merely shows what always happens under certain circumstances. And when we have called something which we do not understand "evolution," or "gravitation," we have merely given a name to our ignorance. Evolution is a process and does not touch first cause. It is the failure to recognize this that has made some scientists, atheists. When Huxley was advancing in years, he said, "Science deals only with second causes; but back of all causes that we know there lies a great first cause, an uncaused cause." The devout scientist is glad to believe that this uncaused cause is the God of Abraham, He who is our Father.

The theory of evolution is only the latest successful attempt to reduce phenomena to law, and Darwin is not the first who suffered persecution from the representatives of religion. Galileo was accused of heresy because he said the earth was round. At that time he made a remark worthy of remembrance. Said he: "The Bible is not to teach men how the heavens go, but to teach men how to go to Heaven." Harvey was called to account when he said that the heart pumped blood instead of being the seat of good and evil. When Newton announced his discovery of gravitation, the anxious pulpit cried out again.

You will notice that all along the scientists have been victorious. One class of phenomena after another has

been reduced to law, and the conviction that all things proceed by law is a rising tide that knows no ebb.

Perhaps the greatest service evolution has rendered will some time be found to be that it has forced us to the conception that law is universal. Either God is the immediate agent of all that is done in nature, or He is so far away that to us He is nothing. We are driven from the old idea that God made the universe and sits by to see it go on by itself, here and there miraculously interfering.

Is this thought-change a loss, and does the victory of evolution take away the glory of the Creator? Which is most like Him we worship—that He should come down to earth for six days and make lion, and beetle, and snail and oak tree, as children make mud pies, or that He produced a world by processes of growth through majestic stretches of time? Does it not accord with our highest notion of the Deity to think of evolution as the divine method of creation and gravitation the divine method of sustentation, these laws unchangeable because He is immutable?

THE PARIS METROPOLITAN RAILROAD.

THE photographs that we reproduce herewith, and which were taken at different working points on the Paris Metropolitan Railroad, will, says Le Monde Illustré, surprise more than one pessimist. The work has advanced to such a point that the vaults are already formed, and the closing in of the street openings will soon be begun; so that, in certain quarters, the street will, ere long, resume its habitual aspect.

Everywhere, from Place de la Nation to the Dauphine gate, the greatest activity prevails, and every one is equally anxious to end the work quickly, so as to be ready for the 14th of January, 1900.

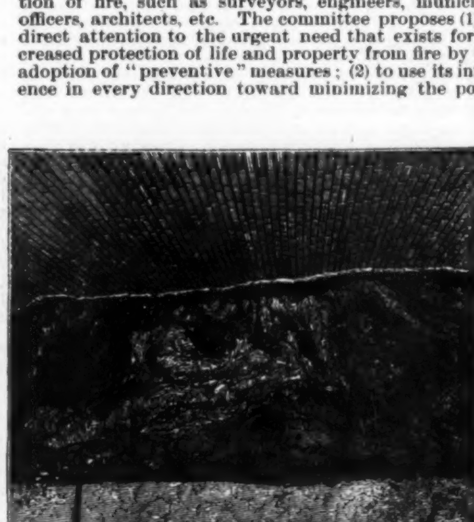
LAYING GLAZED BRICKS OVER THE VAULT AT PLACE DE LA NATION.

At Place de la Nation, where we shall begin, a new process is being applied in the construction of the vault. Instead of beginning by excavating a tunnel, archbuttresses simply are constructed, and then the earth is rounded off. The latter is first covered with a layer of plaster, and upon this are laid hollow glazed bricks, upon which, after they have been cemented, the earth is put back in place. While the masons are advancing from one side in laying these bricks, workmen descend through a shaft to the floor of the future line, where they dig the tunnel and gradually free the glazed ceiling that is protected by the layer of plaster. We give an illustration of this work, in which the line shown at the upper edge under the bricks is formed by the plaster more or less mixed with earth.

From Place de la Nation we now proceed to the work on Boulevard Diderot. Here we reach the tunnel under construction through an entrance formed upon the site of Mazas prison. The somber prison is now completely razed, and its debris still strew the vast quadrilateral that it occupied. The materials derived from its demolition are used in the construction of the vaults of the Metropolitan. Work is here pushing with great activity, and the tunnels have been cleared for quite an appreciable length.

From Boulevard Diderot to Rue de Lyon the line forms a bold curve, in order to take a direction toward the Bastille. From Rue de Lyon we pass to the work at the Bastille. Here the quays are torn up upon the two banks. The tunnel under which the Saint Martin Canal passes is to be prolonged. The work of filling in the canal upon both sides is now going on, nothing being left but a channel in the center for navigation. Here the Metropolitan will emerge and then enter the ground again upon reaching the opposite shore. This latter has particularly occupied the attention of the friends of old Paris. The tearing up of the quay at this point and the prolongation of the tunnel upon Rue Saint-Antoine has brought to light certain vestiges of the Bastille. The old state prison has indeed been razed, but its foundations, which were formidable, have left traces that are still visible. Here we find part of an old staircase, and, just beyond, the laborers discovered a gold earring and a wedding ring. Both relics were carried to the Carnavalet Museum. In Rue Saint-Antoine, upon the very site of the vault that we photographed, there was found a superb dressed stone that marked the limits of the ancient fortress. This stone will eventually be set into a niche in the tunnel, and upon its face will be engraved an inscription relating its origin.

SHIELD AT PLACE DE LA CONCORDE.



WIDENING OF THE VAULT.

From Rue Saint-Antoine one must go to Place Lobau in order to find an interesting working point. This ends at the Seine through a subterranean gallery, which puts the Hôtel de Ville in communication with the barracks of the Republican Guard on one side and the Lobau annex on the other, since this secret tunnel, as every one knows, is double.

The construction of this city system will have to be left in a problematical state as regards the entrance of the great lines into Paris and their connections therein. Such modifications, however, insure the independence of the projected railroad, since, although the city rolling stock will be able to use the lines of the large companies, the size of the Metropolitan tunnels will not permit of a reciprocity.

The law of April 4 last authorized the city to borrow the sum of 165,000,000 francs that was deemed necessary for the construction of the system.

The modification relative to the width of the rolling stock having carried with it an increase of the transverse section of the works, there has resulted a supplementary expense of 15,000,000 francs, and the preceding sum has, consequently, had to be raised to 180,000,000 francs.

The work of construction of line No. 1 and of lines Nos. 2 and 3, respectively, comprised between Place de l'Etoile and the Trocadero and Place de l'Etoile and the Maillot gate, was offered for bids and was begun shortly after it was declared to be of public utility. It is thought that this portion of the system will be ready for use at the opening of the Exposition of 1900.

The total length of the lines to be constructed is about forty miles. The cuttings, after the execution of the work upon Boulevards Courcelles, Batignolles, Clichy and Rochechouart, will be covered with a metallic ceiling and will be protected by gratings. All the metallic work is to be of steel.

The subterranean part of the work is executed by the shield process, which has the great advantage of not interfering with traffic. All the masonry work will be constructed of tufa, concrete, or blocks of the latter moulded and compressed. In the construction of the masonry, facings, joints, etc., cement will be exclusively employed.

The City of Paris is itself executing the work of substructure, tunneling, and excavating, and constructing the viaducts and passenger platforms.

The concession of the operation of the city system to the Compagnie Generale de Traction is granted for a period of thirty-five years. At the expiration of this period the city will assume all the rights of the grantee upon the railroad and its dependencies. It reserves to itself the right to purchase all the rolling stock, equipments, and real estate. The city will be able to effect the purchase of the entire system by May 31, 1934. The following prices will be fixed for the carriage of a passenger from one point to another of the Metropolitan: For the first class, 25 centimes, and for the second, 15 centimes. Independently of the six lines that constitute the system conceded to the Compagnie Generale de Traction, two others are projected—one from the Palais Royal to Place du Danube and one from Auteuil to the Opera House.

There has just been incorporated a new society of about 500 members, known as the British Fire Prevention Committee. Mr. Edwin O. Sachs is the founder and the chairman of the executive. The committee includes officials of all trades or professions who may be either directly or indirectly interested in the prevention of fire, such as surveyors, engineers, municipal officers, architects, etc. The committee proposes (1) to direct attention to the urgent need that exists for increased protection of life and property from fire by the adoption of "preventive" measures; (2) to use its influence in every direction toward minimizing the possibilities and dangers of fire; (3) to undertake such independent investigations and tests of materials, methods, and appliances as may be considered advisable. A testing station is being constructed near the Regent's Canal where such investigations will be carried out. Three test huts have been already put up. The temperature inside these huts can be continuously recorded. This is done by thermo-junctions and reflecting galvanometers of the same type as Sir Roberts-Austen uses at the Mint.

APPARATUS FOR CONSUMING SMOKE.—II.

IN a former article* we have described the first apparatus that received prizes at the competition of smoke consuming devices, and it now remains for us to describe three others.

The Dulac Apparatus.—In this apparatus the grate bars are hollow, and through them circulates water coming from the boiler (Fig. 1).

The grate is prolonged at the upper extremity by a cast iron plate over which the coal rolls and begins to burn. At the bottom the charge abuts against a cylinder, *E*, through which water circulates, and which forms a fire bridge; and the ashes and clinkers accumulate upon the grate, *D*, which is cleaned from time to time.

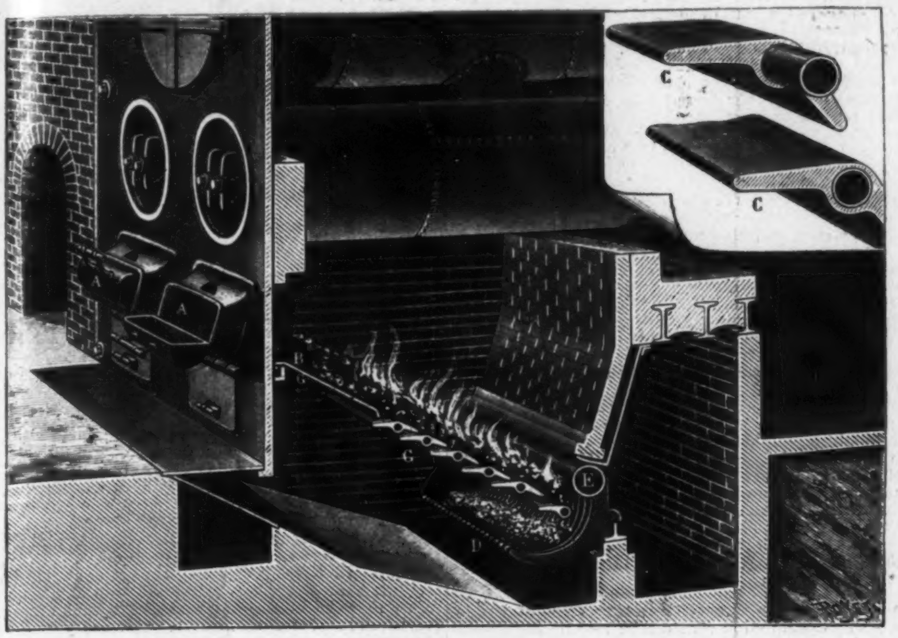


FIG. 1.—THE DULAC SMOKE CONSUMING APPARATUS.

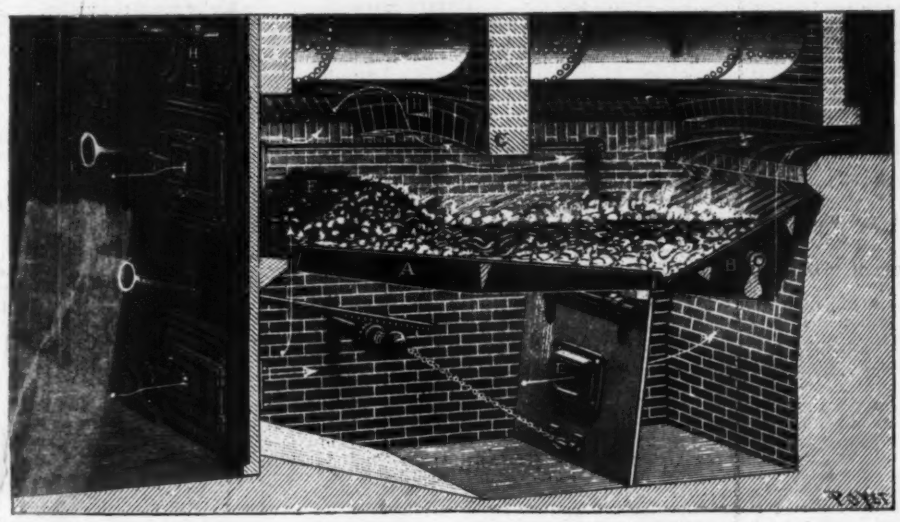


FIG. 2.—THE HINSTIN SMOKE CONSUMING FURNACE.

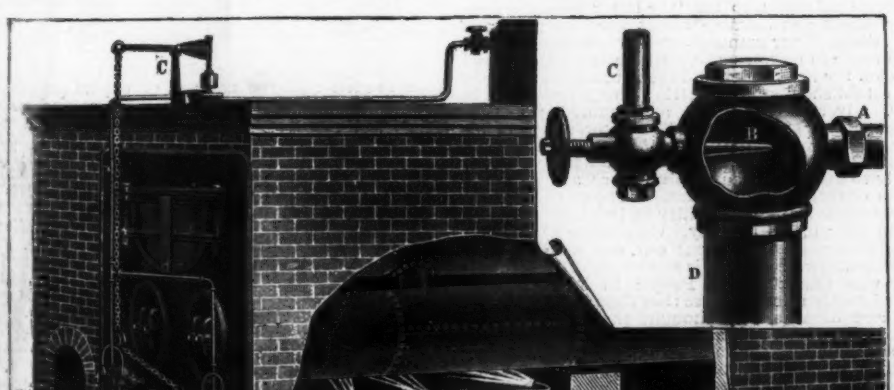


FIG. 3.—THE ORVIS, MULLER & ROGER SMOKE CONSUMING APPARATUS.

This apparatus, which is in use in several municipal works, is recommendable, especially as regards smoke consumption, for the rapidity with which it operates.

The Hinstin Apparatus.—This apparatus, which is quite simple in construction and of comparatively low cost, reproduces the process often employed by stokers for burning smoky coal upon ordinary grates, namely, that of combustion in two periods. In the first period, the coal is thrown upon the front part of the grate, where it becomes heated, and burns progressively; in the second, after it has become partially converted into coke, it is distributed over the entire surface of the grate. This principle is more methodically applied in the Hinstin apparatus, which consists of an ordinary grate, *A*, inclined toward the rear, and followed by another grate, *B*. The furnace is divided into two unequal parts by an arch, *c*, of refractory bricks that serves as a support to a wall that forms a compartment in the combustion chamber. This arch is protected by a mask formed of a perforated cast iron plate. The coal is heaped up on the front part of the grate, where it begins to heat. After the burning has advanced sufficiently, the stoker shoves the coal to the back part of the grate, *A*, and at the same time pushes the already burned residue upon the back grate, *B*, where it is finally entirely consumed.

The ash pit is divided into two chambers by a movable iron damper, *E*, which contains an aperture that is closed by a shutter regulatable by hand and permitting of varying the proportions between the quantity of air that traverses the fresh fuel and that which is nearly spent. A sight hole, *H*, permits of watching the operation of the furnace.

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This apparatus, which has already been installed in one of the large establishments of Paris, is giving results that are highly appreciated therein.

The Orvis, Muller & Roger Apparatus.—This apparatus has an air injector actuated by steam derived from the boiler (Fig. 3). A certain number of such injectors are installed around the furnace at properly selected points. An automatic blowing takes place for a few minutes after each charging, with the aid of special devices.

The blowers consume a quantity of steam varying from 4·38 to 16 per cent. of the boiler production, and since they are capable of operating only on condition of the generator being under charge for the entire period of lighting, they are reduced to inaction and their efficiency (already mediocre of itself) is therefore still further diminished when they are applied to boilers that perform an intermittent service, as is especially the case in many electric works.

The apparatus is easily installed and not very high priced.

For the above particulars and the illustrations we are indebted to La Nature.

* SCIENTIFIC AMERICAN SUPPLEMENT, No. 1205, page 19887.

ADVICE TO EXPORTERS TO CHINA.

IN his annual report (to appear in Commercial Relations, 1897–1898) Consul-General Goodnow, of Shanghai, says that the fact that trade with the United States increased, in spite of the decrease of shipping consequent upon the war with Spain and the disturbed political conditions in China, shows the solid basis of mutual demand. The great staples of export from the United States to China—kerosene and cotton goods—were in greater demand in 1897 than in 1896. The imports from the United States into Shanghai in 1897 were valued at about $8,000,000. He continues:

We do not advertise enough here. I do not mean by this newspaper advertising or advertisement by circulars. These appeal only to the few thousand foreigners sojourning here, but do not reach the hundreds of millions of Chinese. They will learn to appreciate our goods only by seeing them. I do not know to-day where in Shanghai I could buy an American hat or shoe or underwear or collars or furniture or a telephone of improved quality or a magazine. I might make this list much longer. What goods we send here are usually put into the hands of people of other nationalities, who do not exploit them. I hope to see an exposition of American goods here in Shanghai, managed by Americans. It would pay to put one also in Canton and one in Chefoo or Tientsin.

In the next place, we do not cater to the trade here. Our steels mills have not supplied the rails for the railways in Northern China, because the pattern is English, and to make them would necessitate new rolls. The cotton men are just beginning to inquire if the widths, etc., they have been accustomed to make in America are what are really wanted in China. Only one American life insurance company has reached out for this trade with any vigor. If this trade is to be taken and kept by America, its needs, customs, and superstitions must be studied on the ground by experts in each department.

In the third place our merchants must be willing to settle disputes in regard to damages in shipment and disagreements as to quality and breaches of contract, as is done by English and Germans. The average dealer here will pay a higher price for an article if he knows that a cheap and speedy method of settling any possible dispute can be had. Methods of packing, means of transportation, exchange, banking, etc., must be studied by experts, each for his own line of business. But all must show their goods to the Chinese, must study the wants of the trade, and must favor it by facilitating settlements of disputes.

The ease with which the viceroy at Canton was induced to protect, in his province, an American firm in the ownership of certain trade-marks, and the certainty with which the Chinese courts in this city protect foreigners in trade-marks and copyrights, leads me to believe that a treaty protecting our people in their patents, trade-marks, and copyrights may be obtained. The proverbial imitativeness of the Chinese makes such a treaty highly desirable, all the more as our trade grows larger and more varied.

The latest invention is a pipe line made of glass, says The Bradford Era. The glass manufacturing firm whose plant is located at Port Allegany, near Bradford, Pa., is preparing to make glass tubes that can be used for sending oil or gas across the country, for carrying off sewage, supplying cities with water, etc. The glass pipe does not corrode, it is impervious to electrolysis in underground conduits, and it is claimed is less likely to leak than iron pipe. An Ohio company is now putting in such a pipe line, and a practical test of the system will soon be possible for a distance of 100 miles.

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TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Traveling Agents and Foreign Languages.—Consul Warner writes from Leipsic, August 16, 1898, of the value of the knowledge of foreign languages in the foreign commercial business. He says:

Germany furnishes us, undoubtedly, with one of the best examples of real wideawake and up-to-date methods in the struggle for commercial supremacy. Her efforts in China, Africa, and South America in this direction, within the past few years, have demonstrated most conclusively the great benefits to be derived from the possession of a thorough commercial knowledge of the language of these countries. The first move a man makes in this country, who has an idea of entering the export or import business, is to acquaint himself with the language as well as the habits and wants of the people with whom he expects to have dealings.

Our commercial class, contrasted with that of Germany or Belgium, may be perhaps a trifle below the average. Commercial travelers from the countries named can read and speak the language of the people with whom they have relations, while many of ours are unable to make known their wants, much less carry on a business conversation. It cannot be too strongly impressed upon the minds of those interested in commerce that the first thing to be learned is to be able to communicate in an intelligent way with prospective customers. This can only be accomplished by study and application. For a little exertion, we would be rewarded by a large increase in business and greater profits.

Let us look at the United States trade with Germany to-day. It is a fact that a large percentage of our imports to and exports from this country are carried on either by German citizens or German born American citizens. Another thing, a great portion of this trade is transported in German bottoms. By a systematic training, the Germans are taught the value and necessity of the smallest details in connection with commercial life. The German merchants have studied our language, habits, and wants, and by their thrift and perseverance and knowledge of business, are able to control much of the shipping which goes on between the two countries.

While one cannot say too much in commendation of the business men of the empire of Germany and of their methods in connection therewith, one may have earnest hope that our commercial men will take immediate steps toward seeing that young men who have an inclination to enter the mercantile world are afforded opportunities for securing the very best possible commercial education. It will not be long before our business men will learn—if they do not know it now—that time and money will be wasted in sending agents to South America or other countries to solicit trade who do not know the languages of the lands to which they are sent.

Suiting Methods to Scotland.—Our manufacturers should keep constantly in mind the radical differences in the business methods of different countries, and avoid the mistake of assuming that they can extend their sales in one market in the same way that they acquire trade in another. I venture to say that the plan of selling American goods through middlemen, as is often done on the Continent, would not be successful in Scotland. This opinion has been arrived at after experience in making inquiries among business firms and companies, in response to requests from the London and Liverpool agents of American manufacturers and exporters. Almost invariably, I have been told by these firms that they prefer to deal directly with the American producer or exporter. They will not give orders to intermediate firms or companies. The exceptions to this rule are in special lines, such as bicycles, typewriters, electric motors, and other electrical machinery. It is my observation that large buyers of American wares and the best class of small dealers who are progressive buy directly from the producer or his representative in America. They avoid any middleman who is anything more than an agent to take orders to be sent straight to the American manufacturer or exporter. Therefore, a warehouse for American goods here, managed by a company, would be useful only as a sample room. In this respect, undoubtedly, it would be of great benefit if the goods were well advertised.

Most of our manufacturers and exporters are pursuing the right course to secure the widest possible sale of suitable products in Scotland. Their policy is to reach the leading dealers in each important community without the intervention of middlemen. This plan is best adapted to business conditions here and, when supplemented by the usual methods of working up trade—by the personal efforts of a representative of the manufacturer wherever practicable—has been successful and will prove more effective than any other. It has brought splendid results in some branches of trade, and may be expected to continue to swell the sales of American goods.—Rufus Fleming, Consul, Edinburgh, November 18, 1898.

Wooden Boxes for Coal in England.—Under date of November 28, 1898, Consul Halstead, of Birmingham, writes:

The metal coal scuttle found in American homes, painted, japanned, enameled, in many styles and shapes, is not used in England. In its stead, there is used an ornamental hard wood box, made of any one of the different kinds of wood, furnished with a solid stationary brass carrying handle, and a drop lid which conceals a galvanized iron coal box, which slips in and out of the box easily. It is really an attractive piece of furniture for a room, and to my mind is better than the metal coal scuttle. While this box may be used in some parts of the United States, at this present moment I am not able to recollect a single house which has one. I believe our hard wood manufacturers, because of convenient supplies, could not only develop an export trade with these boxes, but would find a ready sale for them in the United States.

Inquiry for Mild Plating Steel in England.—Consul Halstead writes from Birmingham, November 30, 1898:

A large firm of edge tool manufacturers in this city, its line consisting of spades, shovels, forks, axes, adzes, hatchets, picks, trowels, hoes, etc., requests me to obtain for them the names of a few makers of steel suitable for its use. The manufacturers say: "Of course there are numerous varieties used, but our largest purchases are of mild plating steel in bars, sizes running between 2 inches by ⅜ inch to 4 inches by 1 inch."

Demand for Guns in Russia.—The following, dated St. Petersburg, November 24, 1898, has been received from Consul-General Holloway:

I am informed that the Russian government recently contracted a loan of 108,000,000 rubles ($55,512,000) in France, to be used in replacing her artillery with rapid-firing small caliber guns. The trials by experts have been concluded, and the report is said to be in favor of the manufacture of a gun embracing the best points of a number tested. As 6,000 guns will be required within the next two years, and Russia will not be able to manufacture that number, contracts will be made with foreign firms to furnish the remainder.

Labor Saving Devices in China.—In reply to an export association in New York, Consul-General Goodnow, of Shanghai, writes as follows under date of November 3, 1898:

I cannot give you any encouragement in regard to the shipment of wheelbarrows, scrapers, dump cars, and the like to China. The wheelbarrow used here has one large wheel in the middle and a seat on either side, where passengers or loads are carried. Once in a great while, dirt is carried in baskets on such a barrow, but ordinarily it is carried by a coolie in two baskets hung on the end of a bamboo rod balanced on his shoulders. These baskets are about the size and shape of a grain scoop. Labor saving devices are not in demand in China. The cheapest thing here is a man. There is more labor than can find employment. A coolie carrying dirt will receive from 7 to 10 cents gold per day. He must work from sunrise to sunset—not very steadily or very intensely, but putting in a great many hours and accomplishing a large amount of work for the amount of wages paid. There are more coolies willing to work for this pittance than there is work for them to do.

The Report of the French Business Commission to China.—The Commission sent out in 1895 by the Lyons Bureau of Commerce to study the conditions in China has just made public a most important report which will prove of value to Americans who contemplate investing or settling in that country, says Mr. Frank H. Mason, Consul-General of Berlin. The first part of the book is devoted to the description of the travels of the Commission. The second part to a detailed report of the business conditions in the Chinese empire. The third part contains the conclusions of the Commission and their opinion of the possible openings for French commerce. Reports by specialists on mining, silk, oil, and other branches of Chinese industry are especially valuable. According to the Chinese Custom House Reports, the import trade in the United States is given at $24,000,000 per annum, but it is estimated by the Commission at $39,300,000. It is further estimated that forty to fifty per cent. of the foreign trade of China is with Great Britain, and the Commission's conclusion, as drawn from all the facts gathered by the Commission, is that there exists in China a large field for the enterprise of other nations. The report includes 900 pages and has 180 illustrations. It is published by Rey et Cie., Rue Gentil, 4, Lyons, France.

American Bicycles and Vehicles in England.—Consul Halstead, of Birmingham, in England, has, in his annual report, given a very valuable summary of the bicycle and vehicle trade in England as regards American exports. His information was largely obtained from various parties who are engaged in selling American goods. A few years ago American bicycle manufacturers, knowing that, with the use of modern machinery and methods, their manufacturing costs were low, and finding the home market unsteady owing to overproduction, decided to invade foreign markets. Mr. Halstead's informant was one of the first of American bicycle salesmen, so that the latter was in a position to know considerable about the history of the trade. Some of our manufacturers went about getting foreign trade in a systematic, businesslike manner, and worked on the lines which had been successful at home. They established stores, putting competent men in charge, advertised liberally, and quoted prices in pounds, shillings, and pence. Their stores were repair depots where any part of the machine could be repaired, even replaced, if broken. Other manufacturers, desiring only to dispose of surplus stock at any price, regardless of future business, accepted agents of various degrees of financial responsibility and without reference at all to their moral liability. Catalogues with prices in American money were sent out, and as the terminology in the two countries is somewhat different, confusion was unavoidable. People in England were afraid of wooden rims because they thought they would break and because they thought the damp weather would affect them, so that they did not desire them. They also have no faith in the single tube tire, and an English double tube tire company has such a monopoly and controls so many agents that it is useless to fly in the face of facts. A few far-sighted manufacturers supplied steel rims and detachable double tube tires. The manufacturers who came to stay also conformed to the wishes of English riders, as regards brakes, mudguards and gear cases. The result is that the far-sighted manufacturers have found an excellent market in England. Their machines are on a par with or even better than the best English machines and sell at cheaper prices; while the others have not only ruined their prospects and lost money but very nearly spoiled the market for American machines by their loose ways. There are still some American machines which should be sent to England, and, if well represented, would sell rapidly, if they were fitted to meet the demand of the market. There is also a splendid opportunity for bicycle fittings if orders are filled promptly and with exactness. There is a good demand for saddles, hubs, pedals, etc. Sheet steel stampings are also needed, and the high class work of this description turned out in the United States should find a ready sale.

The cycle business for Great Britain for the season just closed has been very disappointing from the manufacturers' point of view. Agents carried over heavy stocks from the preceding year, and were, therefore, not in a position to buy heavily. The makers were obliged to push sales outside the ordinary circles of trade, regardless, more or less, of the financial condition of those with whom they dealt. This has naturally resulted in many bad debts. In regard to 1899 the outlook is much more hopeful. Stocks have been well reduced, and there seems to be no reason for undue cutting of prices as last season. The demand for 1899 will be most for good machines at popular prices. Buyers are not likely to go higher than $50 or $60. The majority of large manufacturers will adopt a net price list instead of fancy figures of the previous years.

One cause of the trouble with the American export bicycle trade is bad packing. In many cases they do not follow the exact specification as to packing and marking, and the report of Consul Halstead cites examples where wheels were broken and the enamel chipped. It is also claimed that American manufacturers do not keep faith in shipping goods, that they send goods which are not up to the standard. This claim may or may not be true, but it must be patent to any American that with this kind of story current, even people anxious to purchase hesitate about paying cash against documents. No merchant or manufacturer can afford to send out anything but the very best. Salesmen should be familiar with the latest American models, and it should be remembered that in England novelties are not wanted. In America people buy a novelty because it is a novelty, and everybody wants to try it, but in England the people prefer something which has been tested. The manufacturer of a good acetylene bicycle lamp tells of one large city in America where more acetylene lamps were sold in one summer than in the whole of Great Britain.

There seems to be a fairly ready sale for other American vehicles. Traps which approach in appearance articles of British manufacture sell well. They must not be too wide and a four-wheeler must positively cut under, and even a three-quarter bar will not do. The British buyer goes to the extreme in his demand for solidity of construction, and this strength must be apparent to the eye. To fulfill the desire of the customer in England there must be bulk, and all this means weight, and weight is what is wanted. There are many more two than four-wheeled vehicles used, and people are satisfied with these. Both city streets and country roads are, as a rule, much narrower than in the United States, and an Englishman does not wish to trust himself and family in a vehicle that does not turn easily; so a four-wheeler must cut under. Consul Halstead says:

Some of the modifications for the English market in the American exhibits at the Royal Agricultural Show, Birmingham, were not, to my mind, satisfactory. The lines, I thought, were not good, and certainly some of the modified vehicles were not as graceful as the true American type or as handsome as the thoroughly British trap. Someone with artistic taste should redraw them, and the American buggy top, which would be so useful in this climate, should be adapted in some better way to the two-wheel carts. They have the balancing of a two-wheeler down to a nicety here, and must have, if there is consideration for the horse; and the difference of balance between buggy top down or up is very great, and some counterbalancing device is necessary. There is nothing here to compare with some of the light spring wagons used in the American cities, and they might find favor, as well as two-wheel delivery carts of an attractive type. It is my belief that the American carriage builder who will make exact copies of several models of good English styles will find a ready sale for them, if willing to accept a reasonable profit. Let him depend upon the cheapness of his wood, the low price of the iron parts, due to the use of up-to-date machinery, and let him win his way in this market by good construction, and leave the introduction of American styles or modifications and improvements on British styles to come later and gradually.

American Flour in Brussels.—I transmit, says Consul Roosevelt, of Brussels, Belgium, translation of a letter addressed to me by Mr. Louis Moulart, proprietor of the Grande Boulangerie Viennoise, No. 42 Rue au Beurre, Brussels, which will explain itself. Mr. Moulart is considered the leading baker in Brussels, and consequently his opinion as to the kinds of flour needed and the manner of exporting same to this market is worthy of particular attention. Mr. Moulart informs me that other bakers in Brussels would be pleased to import American flour, if they could buy same direct from the millers and have it consigned to them, instead of receiving it through middlemen at Antwerp, New York, and elsewhere. His letter reads:

"I take the liberty of submitting some information regarding the importation of American wheat flour. First, we bakers find it very much easier to get our flour from Hungary, for the following reason: I receive at least every month a letter from one or two Budapest mills, giving me quotations and soliciting an order. Five or six weeks afterward I receive the flour free at Brussels, and I pay against sight draft on a Brussels bank against remittance of documents.

"As regards American flour, conditions are much more complicated. Flour consigned to Antwerp is very often offered to us, but at exceedingly high rates; or an Antwerp middleman asks us to give orders for 500 or 1,000 sacks of such quality and brand of flour as may be known to us. When the order is accepted by the mills, we have to wait from six weeks to two and even three months before the merchandise is delivered; and this irregularity in delivering orders hampers regular business connections with your country."

American Broom Handles Wanted in England.—The following, dated Birmingham, February 10, 1899, has been received from Consul Marshal Halstead:

A brush manufacturer here, who has been purchasing broom handles from a merchant firm dealing in articles of American manufacture, writes me asking for the name of a broom handle manufacturer, stating that the firm he buys of has never been able to fully satisfy his needs. In reply to my inquiry, the firm confirms the brush manufacturer's statement, saying:

"We have already been doing business in broom handles with the concern you mention, but owing to the great scarcity of broom handles at the present time, we have some difficulty in supplying them."

I am interested in knowing why there should be a scarcity in American broom handles.

CAST IRON.*

By Dr. R. MOLDENKE.

THE recent tests of cast iron columns, made under the auspices of the building department of New York, brought out very forcibly our comparative lack of knowledge and skill in handling a material which should be peculiarly well adapted for this class of work. The practical condemnation of cast iron for even the simplest of structural members under stress is the natural consequence of the uncertainty existing in the mind of the engineer and founder regarding the interior condition of an otherwise good-looking casting.

In carrying out the numerous processes incidental to the preparation of steel shapes, from the furnace to the erecting shop, a continuous watch may be kept upon the behavior of the metal, imperfections detected with some degree of certainty, and such material at once removed. With cast iron, however, we are practically in the dark, and must depend upon our best judgment and experience. The reason for this state of affairs lies in the great lack of homogeneity in cast iron, this being all the more noticeable as, unlike steel, it is not subjected to subsequent treatment, which, if properly carried out, should remove internal strains and leave the piece amenable to the laws of applied mechanics.

But for the manifest advantages of a material which can be cast into any conceivable shape readily and with a fair chance of success, where would a factor of safety of 20 be tolerated? We are hardly ready as yet to accept machinery built of structural steel, as long as the superior stiffness of heavy cast iron frames and beds is not counterbalanced by too great a cost. This, moreover, in spite of the fact that we have to reckon heavily with the internal strains and consequent warping tendencies of large castings in machine design and construction.

The modern tendency is to raise the elastic limit of the materials we work with, in order that a saving in weight may be effected. Note the astonishment of European engineers when they see our bridges and structural work in general. They call it airiness, and lack of solidity; we, on the other hand, deal with the highest grade of materials and keep the standards at the top notch. There is wisdom in this economy, for greater care bestowed upon smaller quantities leaves us the more of our natural resources to draw from in the desperate grapple for the world's industrial supremacy. Thus cast iron is being studied more than ever, its strength is being raised by changes and improvements in processes, and there is on the market to-day a range of iron from the brittle sash weights, which utilize all that would be dangerous in important work, up to the finest gun metals, and those irons which approach the regular steel castings in many ways.

Very little need be said about the history of cast iron. As a matter of fact, the rate of progress in our day is so great that we can hardly pause to look back, being fully occupied to keep at least abreast of the times, if we are not fortunate enough to be in the lead. Suffice it to say that the earliest attempts to cast iron as such were made in England and date back to the fourteenth century. As the value of everything in those days hinged upon its availability as an instrument of active warfare, we naturally read of the casting of cannon regularly two hundred years later. Our own Carnegie Museum contains two very interesting relics of cast iron made in the days of William Penn. From England, the art of casting iron spread over the Continent and finally came to America.

Until recently, but little attention was given to the general run of foundry work. Iron was very expensive and requirements were not at all severe, specifications being practically unknown. To-day this is different. Competition has put every one on the alert; every point is noticed, and the small economies practiced for centuries in the old country are now being thought more of here since the rich cream has disappeared from what was formerly a happy-go-lucky business. To-day we are on the threshold of a more rational system of working, our practical men giving their best efforts to improve moulding and casting methods, while the scientific end of the trade is making the production of castings a distinct branch of the metallurgy of iron.

According to our general understanding, cast iron is that form of iron which contains more than 1½ per cent. carbon, and from its nature can only be cast into moulds to be of commercial value. A closer examination shows us some limitations to this definition. A thin bar of ordinary cast iron can, under suitable conditions, be heated in the forge and then twisted, thus showing a property at variance with our intuitive feeling of what cast iron should do. Again, many street railway gears are sold as steel because the teeth can stand considerable punishment before breaking, and yet the iron is only an excellent grade of gun metal which has received the additional benefit of some annealing.

Cast iron in its true sense is, therefore, best classed as that grade of iron carrying over 1½ per cent. carbon which, after casting, is not subjected to further heat treatment. Thus pig iron is a true cast iron, for the metal, as it comes from the blast furnace, if of the proper composition, could be used for the direct casting of certain kinds of work, such as ingot moulds. Malleable cast iron, however, is not a true cast iron, for, though the casting process is used, the original refining and subsequent annealing, with its radical metallurgical changes, place this most interesting material in a separate class entirely distinct from both cast iron and cast steel.

We have a variety of cast irons, made by a number of processes. Thus the same metal, melted in different ways, produces differently constituted castings, with a consequent variation in commercial value. This will be seen more fully in the discussion of the processes.

To look first at the material the founder of cast iron must deal with, we find an astonishing variety, all of which are useful in their proper spheres. In general, they are the pig irons and the scrap. The scrap may be classified into the foreign (so called because it is bought in the open market) and the gates, sprues, defective castings, and the like, made by the founder himself, the composition or quality of which he may be supposed to know. In the foreign scrap there are varieties and variations. We have heavy and light machinery scrap, car wheel, stove and miscellaneous scrap, burnt grate bars and the like. The designation usually gives a clew to the quality, which is supplemented by breaking and examining fractures, but taken all in all, without a thorough knowledge of the possibilities of the methods used in mixing and melting charges containing this material, disastrous results are very apt to occur. This is especially the case with the miscellaneous scrap, which may contain the remains of many a burnt out grate bar melted over again—material which should not be taken as a gift when making good work.

The pig irons may be looked upon from the following standpoints. Depending upon the fuel used to make them, they are cold or warm blast charcoal, anthracite, and coke. It would be infringing upon the subject of the blast furnace to go into a detailed discussion. Suffice it to say that anthracite irons are now a rarity, and differ little from those made with coke. The charcoal irons are too expensive for use in anything except high class specialties.

The experience of the writer, so far as the relative value of coke and charcoal irons is concerned, runs about as follows: The cold blast charcoal iron is probably the finest variety made, and taking irons of identical composition for comparison, the charcoal pig is undoubtedly the better, for the apparent reason that in its preparation the chances of oxidation and consequent weakness have been at a minimum. This point may be disputed, for there is too little known about the molecular constitution of both irons to be positive about any statement concerning them. The fact remains that, if the additional safety derived by the proper use of charcoal iron counterbalances the increase in cost, it is to be preferred. To the credit of well made coke iron be it said that this condition exists only in special lines of work.

The second way of classifying pig irons is one rapidly getting out of date, and that is by their fracture. Any one familiar with the variations in fracture produced by higher or lower casting temperatures would be little inclined to buy iron on this basis. Long experience and familiarity with the iron may give an inkling as to the quality of the metal, just as a steel expert can detect much of value from the fracture of a broken forging. But pig iron must be remelted, and many of its characteristic points seen in the fracture disappear in the casting made from it.

The commercial grades of soft, medium, and hard, Nos. 1 to 6; the special grades of foundry, forge, silvery, and mottled irons, as analyzed by a chemist in the shape of an Irishman with a sledge, are being gradually merged into plain pig iron carrying so much silicon, sulphur, phosphorus, manganese, and total carbon.

The range of pig irons, therefore, with which we deal to-day are either high, medium, or low in their constituents other than the iron. For current use, it is still convenient to speak of "Bessemer" iron, which for the foundry means phosphorus below 0·1 per cent., low sulphur, and medium to high silicon; "softeners," which mean silicon between 4 and 8 per cent.; and "ferrosilicon," which means 8 per cent. silicon and above.

The foundry pig irons proper give us the choice between the following compositions: Phosphorus from 0·07 to 2·00 per cent.; silicon, 0·14 to 3·25 per cent.; sulphur, 0·02 to 0·15 per cent.; manganese, 0·30 to 2·00 per cent.; and a total carbon from 2·50 to 4·50 per cent., the proportion of graphite and combined carbon going to make it up depending entirely upon the heat conditions and the amount of silicon, sulphur, manganese, and phosphorus—important in the order named—which may be present. One can readily see that, with the limits above given, there may be an endless series of combinations, and when it is remembered that to be able to predict successful results, as required nowadays, as well as to attain them, close attention must be given to this matter, the lot of that founder who does not believe in chemistry, or rather metallurgy, in his works will eventually become a hard one.

We come now to the process for making cast iron. For the production of castings on a commercial scale, there are practically only two: melting in the cupola or shaft furnace and melting in some form of the reverberatory furnace. The use of crucibles for melting may still be found in experimental work, and possibly in some remote corners of the earth where civilization has not yet given the inhabitants the means of scraping together more dollars, in a given time, by legitimate means. Yet this crucible process is the one calculated to give the cleanest iron. We see this by analogy with crucible steel. The open hearth process can make a material exactly like that from the crucible in composition, yet the latter is much better on account of its freedom from slag and oxidation. The chemical processes have more time, and the last traces of slag rise to the top.

In the reverberatory furnace, often called the straight draught, we have first the melting down of the charge, the rabbling or poling to mix it well and possibly help to clean it, and the slight refining called for by the work or else unavoidable while getting the proper casting temperature. It may be taken as a safe rule to let this refining action be as limited as possible, for the change is internal. It burns out the manganese and silicon in the interior of the bath, distributes finely divided slag, and makes dirty iron, if sufficient time is not given after tapping to let it clear itself, at best an uncertain proceeding.

To look at the matter more closely, we find first, in the charging, the cause of much subsequent trouble. Where the furnace can be charged while hot, that is, where the scrap is no larger than can be got through the ordinary sized doors, it is comparatively easy to arrange melts so that the material easiest fused goes in first and forms a bath for the protection of that charged thereafter. The small scrap would therefore go in first and the pig iron last. To help matters, in case the iron is cleaned before charging, slag may be thrown in, which, when melted, forms a protecting coating on the iron, and thus partly arrests the refining action of the oxygen passing over it.

This coating of slag, however, is by no means a complete protection, for the internal action keeps the bath in motion, fresh particles of iron become exposed, through the slag, manganese and silicon are burned out, which, uniting with the oxidized iron, form slag. If the temperature is high, even carbon will go.

Thus it will be seen that there will always be more or less oxidation, with all the troubles that follow from the very nature of the process, and founders of heavy castings, which must be absolutely free from the surface blemishes caused by gases in the iron, find this very oxidation one of their worst enemies. The logical conclusion would be to melt as fast as can be done without overheating the charge, and when the iron is properly melted and hot enough to cast, let no delay keep it in the furnace, subject to the oxidizing influences of the flame. When heavy scrap is to be used, and the end of a cold furnace is taken out for the purpose of charging, one can readily see that the troubles of the founder are aggravated if anything, for the time of melting down a given weight is doubled or trebled.

So much can be said of the behavior of cast iron in the reverberatory furnace. The fact that the metal does not come in direct contact with the fuel (in the crucible method not even with the flame) keeps the product purer, and hence makes the metal (when good) of high grade, in spite of the unavoidable slight oxidation. Another factor in the comparison of cast iron made in this way with that made in the cupola is the molecular constitution of the respective products. Here we know too little as yet, but this can be said, that a gun cast from refined air furnace iron is undoubtedly better than when cupola metal of exactly the same composition is used. In everyday parlance, the last mentioned iron would be judged to be of a "closer" structure than the first, but what that would mean translated into the language of science remains as yet one of the mysteries of molecular physics.

In the cupola process of melting iron we have a direct contact of the metal with the fuel. Under proper conditions, the oxidation of the iron itself should be less, for that which is unavoidable falls to the manganese first, this uniting with sulphur and protecting the silicon in some measure, the silicon going next. While, therefore, a cupola charge should contain about 15 per cent. more silicon than the castings wanted, when there are high manganese pig irons present, or many scrap car wheels, this loss in silicon may drop to 5 per cent., and even less. Carbon, as a rule, remains stationary, and may even go up by absorption from the fuel, 4·60 per cent. being about the limit under ordinary conditions.

One of the principal sources of danger is the sulphur in the coke. Too much care cannot be given to keep this as low as possible, and many a casting which failed unaccountably may be found full of microscopic cracks due to the absorption of this sulphur by the iron passing over it, resulting in an effect well expressed by the current term "red-shortness," were it steel instead of cast iron. The bulk of our castings are made by the cheap and convenient cupola method. It is still crude, in spite of many attempts to use the surplus heat now lost. It will fall to the lot of another to go fully into the status of foundry practice, this much being given with the view of showing to what influences the iron in the castings we buy has been exposed before pouring. Much more could be said, but we must pass on to the next subject, which is the constitution of cast iron.

It is practically impossible to speak of the physical without taking into consideration the chemical properties of cast iron, and vice versa. A casting freshly broken may be either gray, white, in a condition running between the two, called "mottled," or it may be gray in the center, then mottled, and finally white at the edges. Again, the fracture may show a distinct line separating a gray center from the white chilled rim, as in car wheels and chilled rolls. All of these conditions, whether produced naturally or otherwise, are dependent upon the composition and the thermal changes.

Then we have the crystalline structure, similarly affected. Thus the crystals at the edge of a casting are usually small, and in the harder irons may be seen arranged in layers perpendicular to the surface, causing planes of weakness at abrupt changes in direction on the part of the piece. The interior of the casting, if thick, has larger crystals, and is consequently weaker than the skin. This holds true only if the casting-strains in the piece are not excessive; otherwise we may have the casting in a state of tension such that a comparatively small additional load causes it to give way—the true explanation for many a mysterious failure.

To get rid of such casting-strains in the production of work to be finished up true, very heavy cuts must frequently be taken off. We are all familiar with the strains in pulley arms and rims, and it was the writer's good fortune, in a Western mining region, to see an immense sheave for rope haulage, which had just been taken out of the foundry to clean up, break at the junction of those spokes with the rim where the heat of the sun, shining on part of the wheel, had added the very slight tension necessary to cause the wreck.

Where irons are cast into chills, these casting-strains are increased enormously, as, for instance, in making chilled rolls. We have here a thick shell of chilled iron contracting upon a gray interior. The ends of the rolls being smaller in diameter than the body, a period will be reached in the cooling when they solidify, leaving the interior of the roll still plastic, if not fluid. The amount of contraction of a white iron, from casting to coldness, is about one-fourth inch to the foot, while gray varieties show up only half as much; hence we have an enormous pressure exerted upon the interior of such a roll, which, according to discoveries made in subjecting small bodies of high carbon cast irons to such pressures, should make it a genuine mine for microscopic diamonds.

In looking at the structure of cast iron as it appears to the eye, we have its color run from white to very dark gray. This is a question of the condition of the carbon present. For simplicity, we will say that in white iron the carbon is all combined with the iron in some way; in gray iron it is nearly all mechanically mixed with it, and it may be mixed and combined in varying proportions in the irons, between the dead white and the extra dark gray. The reason for such an appearance may be looked for in the resultant of three variable conditions: the composition, the casting temperature, and the rate of cooling. As to composition, silicon is the most powerful element acting upon the carbon. Its absence keeps the carbon all in the combined state. As it enters into the composition, the tendency on the part of the carbon is to separate out as graphite, this going on until, at nearly 4 per cent. of silicon, the reverse takes place, the iron becoming whiter, though of a different crys-

* Paper read at the November meeting of the Engineers' Society of Western Pennsylvania.

talline structure and color, giving the "silvery" appearance to remelted softeners and ferrosilicons. In these high ranges the property of silicon to replace carbon, to some extent, gives us lower carbon irons.

As before stated, sulphur, manganese, and phosphorus have the same tendency to promote the formation of combined carbon, though in a smaller measure. The physical structures are also different from those produced by silicon, notably the difference in the chill line and in the crystallization of the chilled iron, due to high or low sulphur with the same low silicon. The casting temperature is of great importance in this connection, the general rule being laid down that the hotter the iron, the greater the likelihood to attain a whiter fracture. Thus one iron may be white if cast very hot and gray if cast colder. The rate of cooling comes in here. The thicker the piece, the slower it will cool; so that if a wedge were cast of hot iron, the thin edge might be white and the thick end gray.

One can readily preceive what a delicate matter it sometimes becomes in casting very heavy work, with great variations in the thickness of the sections, to so combine the irons that a composition is obtained which, when hot enough to properly run into the thin webs and ribs, will not become white, or at least not hard enough to cause undue contraction and make machining impossible. The fact that the physical condition of a casting is a resultant of these three variables is often lost sight of by those who write papers and are familiar with the laboratory end of the foundry only. Too much stress cannot be laid upon the absolute necessity of being fully equipped with a practical knowledge of the essentials of founding iron before venturing to advise others upon its metallurgical end.

If we look closely into the character of the various forms of cast iron, as revealed by their microstructure, we find that in the gray irons a polished and etched surface is filled with thin veins of graphite. These are especially distinct when the etching is heavy, and show us that between the crystalline groups of iron there are thin lamellæ of this very weak material. The rupture of a piece of gray iron is therefore along these planes of weakness, and the thin plates of graphite covering the iron crystals hide them from view. A thorough application of the scratch brush will quickly change a gray iron fracture to a white one, though the structure, unlike a genuine white iron, is coarsely crystalline. The application of acids for etching, and very weak solutions of chemicals, which color the iron and its carbides differently, show, moreover, that surrounding these planes of graphite are carbides of iron, from which it was evidently frozen out.

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The heavy etching, necessary to study samples of gray iron, makes it difficult to see much; in fact, in the study of steel and iron, microscopists deplore the lack of illumination, which would allow them to use their highest powers. Here is a problem for the physicist—to furnish a method of illumination, something on the principle of the megaphone in sound. Microscopic investigation on iron and steel requires a vertical reflected illumination, as the specimens cannot be made translucent and oblique reflection promotes incorrect ideas. Can light be so intensified, without undue heating, that we can apply objectives and eye-pieces, giving us an enlargement of 8,000 diameters, instead of only 1,000 attainable at present, with any degree of confidence in the results? Could science only reveal to us a method by which we can see the molecule, what a wonderful stride this would be!

The appearance of the white irons, under the microscope, is quite complex, the high percentage of carbon in solution obliterating many of the characteristic forms seen in steels. Much is still to be done in this line, and the comparatively high percentages of the various impurities in cast iron should make this an interesting field. One thing is patent, and that is, the extreme lack of homogeneity in cast iron. One might say that we have nearly pure iron: iron saturated with carbon, in the shape of several carbides; iron saturated with sulphur, with phosphorus; possibly alloyed with manganese and carbon or with manganese and phosphorus; iron with silicon, and so on, all these mixed in a heterogeneous fashion, though with some pretense of arrangement, based upon their relative freezing points, and the rate of cooling fixed by the thickness of the casting and the nature of the mould.

To this comes the additional complication in the existence of all the constituents in two or more forms. Thus phosphorus is present in two very distinct forms in steel, where they can be readily separated by chemical means, and give very different properties, as the one or the other predominates. In cast iron, where the phosphorus contents may be up to twenty times the Bessemer limit, one can readily look for puzzling conditions. Again, the positions of these deleterious ingredients have their effects, more especially the sulphides present. Sulphide of iron is weak and brittle. It does not diffuse evenly, but rather localizes itself. This may be the cause of some good now and, then, for a high sulphur casting is very dense and impervious to gases, though it is not too strong. It would seem that, in the contraction after casting, the sulphide of iron, which has a low melting point, is forced inward by the outer shell, which is setting. This can readily occur, if the casting is thick enough, and, in fact, may save it from destruction, as the giving way of the fluid sulphide eases up the casting strains considerably. In view of the diffusive properties of some sulphides of iron, this otherwise highly objectionable impurity may have some use, after all. If the veins of sulphide of iron present run along the line of stress applied to the casting in service, its presence will not be noticed specially, but if across it, then a real danger exists. Unless, therefore, special effects are desired, as in ammonia, air, and hydraulic cylinders, sulphur had better be conspicuous by its absence.

(To be continued.)

A simple formula for the capacity of fans of the centrifugal type that is said to be remarkably accurate has, says The Engineering Record, recently been devised by Prof. R. C. Carpenter, of Cornell University. From a large number of experiments it was found that the number of cubic feet of air discharged in one revolution of the fan was equal to the cube of the diameter of the fan expressed in feet, multiplied by the constant 0·5, if there was a free delivery, and 0·4 if the pressure was about that found in ordinary blower practice; or equal to the pressure of 1½ inches of water.

VALUABLE BOOKS.

MAGIC

Stage Illusions and Scientific Diversions, Including Trick Photography.

By ALBERT A. HOPKINS,

Editor of the "Scientific American Cyclopedia of Receipts, Notes and Queries," etc.

This unique work appeals to the professional and the amateur alike and will prove a welcome addition to any library. The illusions are illustrated by the highest class of engravings.

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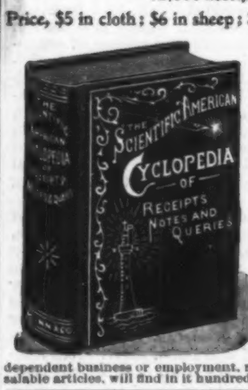

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